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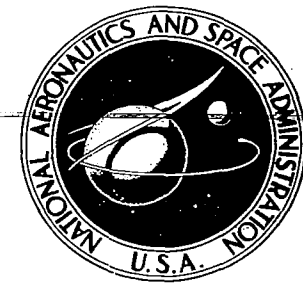

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DESAP 1 - A STRUCTURAL DESIGN PROGRAM WITH STRESS AND DISPLACEMENT CONSTRAINTS

Volume III: Program Listing

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16. ABSTRACT

DESAP 1 is a finite element program for computer-automated, minimum weight design of elastic structures with constraints on stresses (including local instability criteria) and displacements Volume 1 of the report contains the theoretical and user's manual of the program. Sample problems and the listing of the program are included in Volumes 2 and 3, respectively.

The static analysis portion of DESAP 1 is based on the SOLID SAP finite element program developed at the University of California, Berkeley. In design, the stress ratio method is employed for the stress constraints, whereas the displacement constraints are handled by solving the appropriate optimality criterion.

The element subroutines have been organized so as to facilitate additions and changes by the user. As a result, a relatively minor programming effort would be required to make DESAP 1 into a special-purpose program to handle the user's specific design requirements and failure criteria.

DESAP 1 is a companion program of DESAP 2, "A Structural Design Program with Stress and Buckling Constraints." With the exception of a few cards, the same data deck can be used for both programs.

This is Volume 3 of three volumes.

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C*************************************************************************MAIN0200
      DIMENSION A(6000)                                                  MAIN0210
      REAL*8 AD(3000)                                                    MAIN0220
      EQUIVALENCE (A(1),AD(1))                                           MAIN0230
      MTOT=6000                                                          MAIN0240
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      IR=5                                                               MAIN0280
      IW=6                                                               MAIN0290
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      I1=1                                                               MAIN0310
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      I11=11                                                             MAIN0370
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C                                                                        MAIN0410
C-----NUMNP  = NUMBER OF NODE POINTS                                     MAIN0420
C-----NELTYP = NUMBER OF ELEMENT TYPES                                   MAIN0430
C-----LL     = NUMBER OF LOAD CONDITIONS                                 MAIN0440
C-----NUMDV  = NUMBER OF INDEPENDENT DESIGN VARIABLES                    MAIN0450
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    5 READ(IR,1000)HED,NUMNP,NELTYP,LL,NUMDV                             MAIN0470
      IF (NUMNP.EQ.0) STOP                                               MAIN0480
      WRITE (IW,2000)HED,NUMNP,NELTYP,LL,NUMDV                           MAIN0490
C*************************************************************************MAIN0500
C-----DESIGN CONTROL DATA                                                MAIN0510
C                                                                        MAIN0520
C-----KPRINT = PRINT OUT CODE                                            MAIN0530
C            =0 NODAL DISPLACEMENTS NOT PRINTED                          MAIN0540
C            =1 NODAL DISPLACEMENTS ARE PRINTED                          MAIN0550
C-----KPUNCH = PUNCH OUT CODE FOR RESTART DECK                           MAIN0560
C            =0 NO RESTART DECK PUNCHED                                  MAIN0570
C            =1 PUNCHES RESTART DECK FOR DESIGN VARIABLE DATA            MAIN0580
C-----KDISP  = CODE FOR DISPLACEMENT CONSTRAINTS                         MAIN0590
```

```
C             =0 NO DISPLACEMENT CONSTRAINTS ARE PRESENT                        MAIN0600
C             =1 DISPLACEMENT CONSTRAINTS ARE PRESENT                           MAIN0610
C-----NMAXD   = NO. OF MAX. DISPLACEMENT CONSTRAINT RATIOS TO BE                MAIN0620
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C-----NCYCL   = MAX. ALLOWABLE NUMBER OF CRITICAL DESIGNS                       MAIN0660
C-----KONVG   = DESIGN CONVERGENCE CODE                                         MAIN0670
C             =1 DESIGN IS NOT CRITICAL                                         MAIN0680
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C-----NSCALE  = MAX. ALLOWABLE NUMBER OF SUCCESSIVE SCALING OPERATIONS          MAIN0770
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C             =-1 SCALING SHOULD NOT BE USED                                    MAIN0790
C             =0 SCALING IS APPROXIMATE. REANALYSE SCALED STRUCTURE             MAIN0800
C             =1 SCALING IS EXACT. STIFFNESS IS PROPORTIONAL TO SIZE            MAIN0810
C             =2 SCALING IS EXACT. STIFFNESS IS PROPORTIONAL TO (SIZE)**2       MAIN0820
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      IDESN=0                                                                   MAIN0920
      ICYCL=0                                                                   MAIN0930
      ISCALE=0                                                                  MAIN0940
      NMAXD=2                                                                   MAIN0950
      WTMIN=1.0E20                                                              MAIN0960
      IWTMIN=0                                                                  MAIN0970
      READ(IR,1001) NCYCL,NSCALE,KSCALE,DELTA,EPSIL,KPUNCH,KPRINT,KDISP,       MAIN0980
     1 OMEGA,ALPA                                                               MAIN0990
      IF(NSCALE.EQ.0) NSCALE=3                                                  MAIN1000
      IF(DELTA.EQ.0.0) DELTA=0.05                                               MAIN1010
      IF(EPSIL.EQ.0.0) EPSIL=0.1                                                MAIN1020
      IF(OMEGA.EQ.0.) OMEGA=0.8                                                 MAIN1030
      DELTA1=1.0-DELTA                                                          MAIN1040
      DELTA2=1.0+DELTA                                                          MAIN1050
      WRITE(IW,2001) NCYCL,KSCALE,DELTA,EPSIL,KDISP,OMEGA,ALPA                  MAIN1060
C*****************************************************************************MAIN1070
C-----DESIGN VARIABLE DATA---AOLD ON I1,AMIN ON I11                             MAIN1080
C*****************************************************************************MAIN1090
      M1=1                                                                      MAIN1100
      N1=M1+NUMDV                                                               MAIN1110
      N2=N1+NUMDV                                                               MAIN1120
      N3=N2+NUMDV                                                               MAIN1130
      IF(N3.GT.MTOT) CALL ERROR (N3-MTOT)                                       MAIN1140
      CALL DEVAR(A(M1),A(N1),A(N2),NUMDV,I1,I11,IR,IW)                          MAIN1150
C*****************************************************************************MAIN1160
C-----NODE DATA---ID ARRAY STORED ON I8                                         MAIN1170
C*****************************************************************************MAIN1180
      N2=N1+6*NUMNP                                                             MAIN1190
```

```
      N3=N2+NUMNP                                                       MAIN1200
      N4=N3+NUMNP                                                       MAIN1210
      N5=N4+NUMNP                                                       MAIN1220
      N6=N5+NUMNP                                                       MAIN1230
      IF(N6.GT.MTOT) CALL ERROR(N6-MTOT)                                MAIN1240
      CALL INPUTJ(A(N1),A(N2),A(N3),A(N4),A(N5),NUMNP,NEQ,IR,IW)        MAIN1250
C*****************************************************************     MAIN1260
C-----ELEMENT DATA --- UNIT STIFFNESS AND LOAD DATA ON I12               MAIN1270
C     UNIT STRESS RECOVERY DATA ON IR                                   MAIN1280
C*****************************************************************     MAIN1290
      MBAND=0                                                           MAIN1300
      NUMEL=0                                                           MAIN1310
      REWIND I12                                                        MAIN1320
      NBOUND=0                                                          MAIN1330
      DO 900 M=1,NELTYP                                                 MAIN1340
      READ(IR,1002) NPAR                                                MAIN1350
      WRITE(IW,1002)NPAR                                                MAIN1360
      NUMEL=NUMEL+NPAR(2)                                               MAIN1370
      MTYPE=NPAR(1)                                                     MAIN1380
      IF(MTYPE.EQ.7) NBOUND=NPAR(2)                                     MAIN1390
  900 CALL ELTYPE (A,MTOT,MTYPE,IW)                                     MAIN1400
C*****************************************************************     MAIN1410
C-----WRITE UNIT WEIGHT ARRAY ON IR AND REARRANGE STORAGE OF ID          MAIN1420
C*****************************************************************     MAIN1430
      CALL UNITWT (A(M1),IR,NUMDV)                                      MAIN1440
      J=6*NUMNP                                                         MAIN1450
      DO 121  I=1,J                                                     MAIN1460
  121 A(I)=A(NUMDV+I)                                                   MAIN1470
C*****************************************************************     MAIN1480
C-----ELEMENT LOAD MULTIPLIERS---STORED ON UNIT I11                     MAIN1490
C*****************************************************************     MAIN1500
      N1=1                                                              MAIN1510
      N2=N1+6*NUMNP                                                     MAIN1520
      CALL ELMULT(A(N2),LL,IR,IW,I11)                                   MAIN1530
      M=LL                                                              MAIN1540
      IF(KDISP.EQ.0) GO TO 110                                          MAIN1550
C*****************************************************************     MAIN1560
C-----READ IN DISPLACEMENT CONSTRAINTS AND WRITE ON UNIT I12            MAIN1570
C     CONSTRAINTS SHOULD END WITH ONE BLANK CARD                        MAIN1580
C     IF NO DISPLACEMENT CONSTRAINTS,DON'T LEAVE ANY BLANK CARDS        MAIN1590
C*****************************************************************     MAIN1600
      N3=N2+12*LL                                                       MAIN1610
      MN=MTOT-N3                                                        MAIN1620
      CALL INPUTD(A(N1),A(N2),A(N3),MN,NUMNP,LL,LD,IR,IW,I12)           MAIN1630
C*****************************************************************     MAIN1640
C-----NODAL LOADS AND MASSES -- STORED ON UNIT I11                      MAIN1650
C*****************************************************************     MAIN1660
      IF(M.LT.MMAXD) M=MMAXD                                            MAIN1670
  110 MEQB=(MTOT-4*LL)/((MBAND+M)*4+1)                                  MAIN1680
      NBLOCK=(NEQ-1)/MEQB +1                                            MAIN1690
      IF (MEQB.GT.NEQ) MEQB=NEQ                                         MAIN1700
      N3=N2+6*LL                                                        MAIN1710
      ND3=(N3-1)/2+1                                                    MAIN1720
      N4=(ND3+MEQB*LL*2)*2                                              MAIN1730
      IF(N4.GT.MTOT) CALL ERROR(N4-MTOT)                                MAIN1740
      CALL INL(A(N1),A(N2),A(ND3),        NUMNP,MEQB,LL,IR,IW,I11)      MAIN1750
      WRITE (IW,2002)                                                   MAIN1760
      WRITE (IW,2003)NEQ,MBAND,MEQB,NBLOCK                              MAIN1770
      WRITE (IW,2002)                                                   MAIN1780
C*****************************************************************     MAIN1790
```

```
C-----FORM ELEMENT STIFFNESS AND LOAD VECTOR AND WRITE ON UNIT I2        MAIN1800
C*************************************************************************MAIN1810
  995 N1=1                                                                MAIN1820
      CALL ELSTIF (A(N1),NUMDV,NUMEL,I1,I2,I11,I12)                       MAIN1830
C*************************************************************************MAIN1840
C-----FORM STRUCTURAL STIFFNESS AND LOAD VECTORS AND WRITE ON UNIT I10   MAIN1850
C*************************************************************************MAIN1860
      NE2B=2*NEQB                                                         MAIN1870
      ND2=N1+NE2B*MBAND                                                   MAIN1880
      ND4=ND2+NE2B *LL                                                    MAIN1890
      N4=(ND4-1)*2+1                                                      MAIN1900
      N5=N4+4*LL                                                          MAIN1910
      IF(N5.GT.MTOT) CALL ERROR(N5-MTOT)                                  MAIN1920
      CALL ADDSTF(AD(N1),AD(ND2),        A(N4),NUMEL,NBLOCK,NE2B,LL,      MAIN1930
     1 MBAND,I2,I9,I10,I11)                                               MAIN1940
C*************************************************************************MAIN1950
C-----SOLVE FOR DISPLACEMENT UNKNOWNS                                     MAIN1960
C*************************************************************************MAIN1970
      NSB=(MBAND+LL    )*NEQB                                             MAIN1980
      N2=N1+NEQB                                                          MAIN1990
      ND2=N2/2+1                                                          MAIN2000
      ND3=ND2+NSB                                                         MAIN2010
      CALL USOL  (A(N1),AD(ND2),AD(ND3),NEQB,MBAND,LL,NBLOCK,NSB,I10,I3,MAIN2020
     1 I9,I2,IW)                                                          MAIN2030
      IF(KDISP.EQ.0) GO TO 150                                            MAIN2040
C*************************************************************************MAIN2050
C-----FIND OUT FOUR MAXIMUM DISPLACEMENT CONSTRAINT RATIOS                MAIN2060
C*************************************************************************MAIN2070
      N2=N1+LD                                                            MAIN2080
      N3=N2+LD*LL*2                                                       MAIN2090
      ND3=N3/2+1                                                          MAIN2100
      MN=(ND3+NEQB*LL-1)*2-MTOT                                           MAIN2110
      IF(MN.GT.0) CALL ERROR(MN)                                          MAIN2120
      CALL MAXD(A(N1),A(N2),AD(ND3),NEQB,LL,LD,NBLOCK,I2,I12,IW,NMAXD)    MAIN2130
C*************************************************************************MAIN2140
C-----PRINT NODAL DISPLACEMENTS                                           MAIN2150
C*************************************************************************MAIN2160
  150 N2=N1+NUMNP*6                                                       MAIN2170
      ND2=N2/2+1                                                          MAIN2180
      ND3=ND2+6*LL                                                        MAIN2190
      WRITE(IW,2004)IDESN                                                 MAIN2200
      CALL PRINTD(A(N1),AD(ND2),AD(ND3),NEQB,NUMNP,LL,NBLOCK,NEQ,I2,I8,   MAIN2210
     . IW,KPRINT)                                                         MAIN2220
C*************************************************************************MAIN2230
C-----COMPUTE STRESSES AND CARRY OUT FULLY STRESSED DESIGN                MAIN2240
C*************************************************************************MAIN2250
      M1=1                                                                MAIN2260
      M2=M1+NUMDV                                                         MAIN2270
      M3=M2+NUMDV                                                         MAIN2280
      N1=M3+NUMDV                                                         MAIN2290
      N2=N1+4*LL                                                          MAIN2300
      ND2=N2/2+1                                                          MAIN2310
      N3=(ND2-1+NEQB*LL)*2+1                                              MAIN2320
      LB=(MTOT-N3)/NEQ                                                    MAIN2330
      IF (LB.GE.1) GO TO 31                                               MAIN2340
      MM=NEQ+N3                                                           MAIN2350
      CALL ERROR (MM-MTOT)                                                MAIN2360
   31 IF(LB.GT.LL)LB=LL                                                   MAIN2370
      CALL STRESS(A(M1),A(M2),A(M3),A(N1),AD(ND2),A(N3),LL,LB,NEQ,NUMDV,MAIN2380
     1 NEQB,A,MTOT,I1,I2,I8,I11,IW)                                       MAIN2390
```

```
C*************************************************************************MAIN2400
C-----EVALUATE CURRENT DESIGN AND PERFORM  REDESIGN                       MAIN2410
C*************************************************************************MAIN2420
      IF (NCYCL.EQ.0) GO TO 996                                           MAIN2430
      M4=M3+NUMDV                                                         MAIN2440
      CALL DESIGN(A(M1),A(M2),A(M3),A(M4),NUMDV,I1,I8,I11,IW,IP)          MAIN2450
      IDESN=IDESN+1                                                       MAIN2460
      IF(KONVG.EQ.4) GO TO 996                                            MAIN2470
      IF(NDISP.EQ.0) GO TO 995                                            MAIN2480
C*************************************************************************MAIN2490
C-----CALCULATE DISPLACEMENT DERIVATIVES                                  MAIN2500
C*************************************************************************MAIN2510
      MTOT2= MTOT/2                                                       MAIN2520
      CALL DDERV( A,AD,MTOT,MTOT2,NBOUND)                                 MAIN2530
C*************************************************************************MAIN2540
C-----CARRY OUT DISPLACEMENT REDESIGN                                     MAIN2550
C*************************************************************************MAIN2560
      M1=1                                                                MAIN2570
      M2=M1+NUMDV*NDISP                                                   MAIN2580
      M3=M2+NUMDV                                                         MAIN2590
      M4=M3+NUMDV                                                         MAIN2600
      M5=M4+NUMDV                                                         MAIN2610
      M6=M5+NUMDV                                                         MAIN2620
      M7=M6+NUMDV                                                         MAIN2630
      MM=M7+NUMDV-MTOT                                                    MAIN2640
      CALL DDESIN(A(M1),A(M2),A(M3),A(M4),A(M5),A(M6),A(M7),NUMDV,NDISP,MAIN2650
     1 I1,I3,I8,IW)                                                       MAIN2660
      IF(KONVG.NE.4) GO TO 995                                            MAIN2670
  996 STOP                                                                MAIN2680
 1000 FORMAT(20A4/6I5)                                                    MAIN2690
 1001 FORMAT(3I5,2F10.0,3I5,2F10.5)                                       MAIN2700
 1002 FORMAT (14I5)                                                       MAIN2710
 2000 FORMAT(1H1,20A4//                                                   MAIN2720
     .  28H  NUMBER OF NODAL POINTS    =  ,I5/                           MAIN2730
     .  28H  NUMBER OF ELEMENT TYPES   =  ,I5/                           MAIN2740
     .  28H  NUMBER OF LOAD CASES      =,I5/                             MAIN2750
     .  28H  NUMBER OF DES. VARIABLES =,I5   )                           MAIN2760
 2001 FORMAT(// 22H  DESIGN CONTROL DATA //                               MAIN2770
     1            9H  NCYCL =,I5/                                        MAIN2780
     2            9H  KSCALE=,I5/                                        MAIN2790
     3            9H  DELTA =,E12.4/                                     MAIN2800
     4            9H  EPSIL =,E12.4/                                     MAIN2810
     5            9H  KDISP =,I5/                                        MAIN2820
     6            9H  OMEGA =,F10.5/                                     MAIN2830
     7            9H  ALPA  =,F10.5 )                                    MAIN2840
 2002 FORMAT(//)                                                          MAIN2850
 2003 FORMAT(34H  TOTAL NUMBER OF EQUATIONS       =,I5,                   MAIN2860
     1      /34H  BANDWIDTH                      =,I5,                   MAIN2870
     2      /34H  NUMBER OF EQUATIONS IN A BLOCK =,I5,                   MAIN2880
     3      /34H  NUMBER OF BLOCKS               =,I5)                   MAIN2890
 2004 FORMAT(31H1*****************************/                          MAIN2900
     1       26H ANALYSIS OF DESIGN NUMBER,I4  /                         MAIN2910
     2       31H *****************************//)                       MAIN2920
      END                                                                 MAIN2930
```

```
      SUBROUTINE INPUTJ(ID,X,Y,Z,T,NUMNP,NEQ,IA,IR,IW)                  MAIN2940
C*****************************************************************MAIN2950
C-----READ OR  GENERATE NODAL POINT DATA                            MAIN2960
C*****************************************************************MAIN2970
      DIMENSION X(NUMNP),Y(NUMNP),Z(NUMNP),ID(NUMNP,6),T(NUMNP)     MAIN2980
      REWIND IR                                                     MAIN2990
      WRITE(IW,2000)                                                MAIN3000
      WRITE(IW,2001)                                                MAIN3010
      NOLD=0                                                        MAIN3020
   10 READ (IR,1000)N,(ID(N,I),I=1,6),X(N),Y(N),Z(N),KN,T(N)        MAIN3030
      WRITE(IW,2002)N,(ID(N,I),I=1,6),X(N),Y(N),Z(N),KN,T(N)        MAIN3040
C*****************************************************************MAIN3050
C-----CHECK IF GENERATION IS REQUIRED                               MAIN3060
C*****************************************************************MAIN3070
      IF(NOLD.EQ.0) GO TO 50                                        MAIN3080
      DO 20 I=1,6                                                   MAIN3090
      IF(ID(N,I).EQ.0.AND.ID(NOLD,I).LT.0) ID(N,I)=ID(NOLD,I)       MAIN3100
   20 CONTINUE                                                      MAIN3110
      IF(KN.EQ.0) GO TO 50                                          MAIN3120
      NUM=(N-NOLD)/KN                                               MAIN3130
      NUMN=NUM-1                                                    MAIN3140
      IF(NUMN.LT.1) GO TO 50                                        MAIN3150
      XNUM=NUM                                                      MAIN3160
      DX=(X(N)-X(NOLD))/XNUM                                        MAIN3170
      DY=(Y(N)-Y(NOLD))/XNUM                                        MAIN3180
      DZ=(Z(N)-Z(NOLD))/XNUM                                        MAIN3190
      DT=(T(N)-T(NOLD))/XNUM                                        MAIN3200
      K=NOLD                                                        MAIN3210
      DO 30 J=1,NUMN                                                MAIN3220
      KK=K                                                          MAIN3230
      K=K+KN                                                        MAIN3240
      X(K)=X(KK)+DX                                                 MAIN3250
      Y(K)=Y(KK)+DY                                                 MAIN3260
      Z(K)=Z(KK)+DZ                                                 MAIN3270
      T(K)=T(KK)+DT                                                 MAIN3280
      DO 30 I=1,6                                                   MAIN3290
      ID(K,I)=ID(KK,I)                                              MAIN3300
      IF (ID(K,I).GT.1) ID(K,I)=ID(KK,I)+KN                         MAIN3310
   30 CONTINUE                                                      MAIN3320
   50 NOLD=N                                                        MAIN3330
      IF(N.NE.NUMNP) GO TO 10                                       MAIN3340
C*****************************************************************MAIN3350
C-----PRINT ALL NODAL POINT DATA                                    MAIN3360
C*****************************************************************MAIN3370
      WRITE (IW,2003)                                               MAIN3380
      WRITE (IW,2001)                                               MAIN3390
      WRITE (IW,2005) (N,(ID(N,I),I=1,6),X(N),Y(N),Z(N),T(N),N=1,NUMNP) MAIN3400
C*****************************************************************MAIN3410
C-----NUMBER UNKNOWNS AND SET MASTER NODES NEGATIVE                  MAIN3420
C*****************************************************************MAIN3430
      NEQ=0                                                         MAIN3440
      DO 60 N=1,NUMNP                                               MAIN3450
      DO 60 I=1,6                                                   MAIN3460
      ID(N,I)=IABS(ID(N,I))                                         MAIN3470
      IF(ID(N,I)-1) 57,58,59                                        MAIN3480
   57 NEQ=NEQ+1                                                     MAIN3490
      ID(N,I)=NEQ                                                   MAIN3500
      GO TO 60                                                      MAIN3510
   58 ID(N,I)=0                                                     MAIN3520
      GO TO 60                                                      MAIN3530
```

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   59 ID(N,I)=-ID(N,I)                                                  MAIN3540
   60 CONTINUE                                                          MAIN3550
      WRITE(IW,2004) (N,(ID(N,I),I=1,6),N=1,NUMNP)                      MAIN3560
      WRITE(I8) ID                                                      MAIN3570
      RETURN                                                            MAIN3580
 1000 FORMAT (7I5,3E10.0,I5,E10.0)                                      MAIN3590
 2000 FORMAT(// 23H NODAL POINT INPUT DATA )                            MAIN3600
 2001 FORMAT (5HONODE,3X,24HBOUNDARY CONDITION CODES,3X,                MAIN3610
     139H/------NODAL POINT COORDINATES--------//,                      MAIN3620
     27H NUMBER,2X,1HX,4X,1HY,4X,1HZ,3X,2HXX,3X,2HYY,3X,2HZZ,12X,       MAIN3630
     31HX,12X,1HY,12X,1HZ,12X,1HT/)                                     MAIN3640
 2002 FORMAT (I5,6I5,3E13.3,I5,E13.3)                                   MAIN3650
 2003 FORMAT (// 21H GENERATED NODAL DATA)                              MAIN3660
 2004 FORMAT (// 17H EQUATION NUMBERS//                                 MAIN3670
     1 35H    N     X     Y     Z    XX    YY    ZZ  / (7I5))          MAIN3680
 2005 FORMAT (I5,6I5,4E13.3)                                            MAIN3690
      END                                                               MAIN3700
```

```
      SUBROUTINE DEVAR(UWT,AOLD,AMIN,NDVAR,I1,I11,IR,IW)                MAIN3710
C*********************************************************************MAIN3720
C-----READ OR GENERATE DESIGN VARIABLE DATA                            MAIN3730
C*********************************************************************MAIN3740
      DIMENSION AOLD(NDVAR),AMIN(NDVAR),UWT(NDVAR)                      MAIN3750
      REWIND I1                                                         MAIN3760
      REWIND I11                                                        MAIN3770
      NOLD=0                                                            MAIN3780
      WRITE (IW,100)                                                    MAIN3790
    9 READ(IR,101)N,AOLD(N),AMIN(N)                                     MAIN3800
      NN=N-1                                                            MAIN3810
      IF(NN.EQ.NOLD)GO TO 11                                            MAIN3820
      KK=NOLD+1                                                         MAIN3830
      DO 10 I=KK,NN                                                     MAIN3840
      AOLD(I)=AOLD(N)                                                   MAIN3850
   10 AMIN(I)=AMIN(N)                                                   MAIN3860
   11 NOLD=N                                                            MAIN3870
      IF(N.LT.NDVAR)GO TO 9                                             MAIN3880
      DO 13 N=1,NDVAR                                                   MAIN3890
      UWT(N)=0.                                                         MAIN3900
      IF(AOLD(N).LT.AMIN(N))AOLD(N)=AMIN(N)                             MAIN3910
   13 WRITE(IW,102)N,AOLD(N),AMIN(N)                                    MAIN3920
      WRITE (I1) AOLD                                                   MAIN3930
      WRITE(I11) AMIN                                                   MAIN3940
      RETURN                                                            MAIN3950
  100 FORMAT(// 35H DESIGN VARIABLE INPUT DATA         //               MAIN3960
     1          33H  DESIGN                           /                MAIN3970
     2          35H  VARIABLE    INITIAL   MIN ALLOWABLE/              MAIN3980
     3          35H  NUMBER       VALUE       VALUE     /)             MAIN3990
  101 FORMAT(I5,2E10.0)                                                 MAIN4000
  102 FORMAT(I6,2X,2E13.4)                                              MAIN4010
      END                                                               MAIN4020
```

```
      SUBROUTINE ELTYPE (A,MTOT,MTYPE,IW)                                MAIN4030
C*****************************************************************************MAIN4040
C-----CALL APPROPRIATE ELEMENT SUBROUTINE TO DEVELOP ELEMENT MATRICES    MAIN4050
C*****************************************************************************MAIN4060
      DIMENSION A(MTOT)                                                  MAIN4070
      GO TO (1,2,3,4,5,6,7,8),MTYPE                                      MAIN4080
C*****************************************************************************MAIN4090
C-----THREE DIMENSIONAL TRUSS ELEMENTS                                   MAIN4100
C*****************************************************************************MAIN4110
    1 CALL TRUSS (A,MTOT)                                                MAIN4120
      GO TO 900                                                          MAIN4130
C*****************************************************************************MAIN4140
C-----THREE DIMENSIONAL BEAM ELEMENTS                                    MAIN4150
C*****************************************************************************MAIN4160
    2 CALL BEAM (A,MTOT)                                                 MAIN4170
      GO TO 900                                                          MAIN4180
C*****************************************************************************MAIN4190
C-----PLANE STRESS ELEMENTS                                              MAIN4200
C*****************************************************************************MAIN4210
    3 CALL PLANE (A,MTOT)                                                MAIN4220
      GO TO 900                                                          MAIN4230
C*****************************************************************************MAIN4240
C-----SHEAR PANEL ELEMENTS                                               MAIN4250
C*****************************************************************************MAIN4260
    4 CALL SHEAR (A,MTOT)                                                MAIN4270
      GO TO 900                                                          MAIN4280
C*****************************************************************************MAIN4290
C-----PROVISION FOR OTHER TYPES OF ELEMENTS                              MAIN4300
C*****************************************************************************MAIN4310
    5 CALL NOELEM(MTYPE,0,IW)                                            MAIN4320
      GO TO 900                                                          MAIN4330
C*****************************************************************************MAIN4340
C-----PLATE/SHELL ELEMENTS                                               MAIN4350
C*****************************************************************************MAIN4360
    6 CALL SHELL (A,MTOT)                                                MAIN4370
      GO TO 900                                                          MAIN4380
C*****************************************************************************MAIN4390
C-----BOUNDARY ELEMENTS                                                  MAIN4400
C*****************************************************************************MAIN4410
    7 CALL BOUND (A,MTOT)                                                MAIN4420
      GO TO 900                                                          MAIN4430
C*****************************************************************************MAIN4440
C-----PROVISION FOR OTHER TYPES OF ELEMENTS                              MAIN4450
C*****************************************************************************MAIN4460
    8 CALL NOELEM(MTYPE,0,IW)                                            MAIN4470
  900 RETURN                                                             MAIN4480
      END                                                                MAIN4490


      SUBROUTINE NOELEM (MTYPE,KODE,IW)                                  MAIN4500
C*****************************************************************************MAIN4510
C-----PRINT THE MESSAGE THAT REQUIRED ELEMENT SUBROUTINE IS MISSING      MAIN4520
C*****************************************************************************MAIN4530
      WRITE (IW,100) MTYPE                                               MAIN4540
      IF (KODE.NE.0) WRITE (IW,101) KODE                                 MAIN4550
      STOP                                                               MAIN4560
  100 FORMAT (//46H THE FOLLOWING ELEMENT HAS NOT BEEN PROGRAMED:        MAIN4570
     1        14H ELEMENT TYPE=,I2)                                       MAIN4580
  101 FORMAT(  14H CONSTRN CODE=,I2)                                     MAIN4590
      END                                                                MAIN4600
```

```
      SUBROUTINE UNITWT(UWT,IR,NUMDV)                                   MAIN4610
C*************************************************************************MAIN4620
C-----WRITE UNIT WEIGHT ON TAPE IR                                      MAIN4630
C*************************************************************************MAIN4640
      DIMENSION UWT(NUMDV)                                              MAIN4650
      WRITE(IR)UWT                                                      MAIN4660
      RETURN                                                            MAIN4670
      END                                                               MAIN4680


      SUBROUTINE ELMULT(STR,LL,IR,IW,III)                               MAIN4690
C*************************************************************************MAIN4700
C-----READ IN STRUCTURE LOAD MULTIPLIERS                                MAIN4710
C*************************************************************************MAIN4720
      DIMENSION STR(4,LL)                                               MAIN4730
      WRITE(IW,2000)                                                    MAIN4740
      DO 50 L=1,LL                                                      MAIN4750
      READ(IR,1002) (STR(I,L),I=1,4)                                    MAIN4760
   50 WRITE(IW,2002) L,(STR(I,L),I=1,4)                                 MAIN4770
      WRITE (III) STR                                                   MAIN4780
      RETURN                                                            MAIN4790
 1002 FORMAT (4F10.0)                                                   MAIN4800
 2000 FORMAT(//10H STRUCTURE,12X,26HSTRUCTURE LOAD MULTIPLIERS/         MAIN4810
     . 10H LOAD CASE,9X,1HA,9X,1HB,9X,1HC,9X,1HD/ )                     MAIN4820
 2002 FORMAT ( I6,7X,4F10.3)                                            MAIN4830
      END                                                               MAIN4840


      SUBROUTINE INTERP (F,EE,NUMTC,NUMMAT,NUM1,NUM2,NT,MAT,TEMP)       MAIN4850
C*************************************************************************MAIN4860
C-----INTERPOLATES MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE  MAIN4870
C*************************************************************************MAIN4880
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN4890
      REAL*4 E                                                          MAIN4900
      DIMENSION F(NUMTC,NUM1,NUMMAT),EE(NUM2)                           MAIN4910
      IF(NT.NE.1) GO TO 220                                             MAIN4920
      DO 210 KK=1,NUM2                                                  MAIN4930
  210 EE(KK)=F(1,KK+1,MAT)                                              MAIN4940
      GO TO 260                                                         MAIN4950
  220 DO 230 I=2,NT                                                     MAIN4960
      II=I                                                              MAIN4970
      T1=F(I-1,1,MAT)                                                   MAIN4980
      T2=F(I,1,MAT)                                                     MAIN4990
      IF(T2.GE.TEMP) GO TO 240                                          MAIN5000
  230 CONTINUE                                                          MAIN5010
  240 R1=(T2-TEMP)/(T2-T1)                                              MAIN5020
      R2=(TEMP-T1)/(T2-T1)                                              MAIN5030
      DO 250 KK=1,NUM2                                                  MAIN5040
  250 EE(KK)=F(II-1,KK+1,MAT)*R1+F(II,KK+1,MAT)*R2                      MAIN5050
  260 RETURN                                                            MAIN5060
      END                                                               MAIN5070
```

```
      SUBROUTINE CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDVAR,IEX,FRC) MAIN5080
C*********************************************************************MAIN5090
C-----CALCULATE BANDWIDTH  OF STRUCTURE STIFFNESS MATRIX               MAIN5100
C-----WRITE UNIT STRESS RECOVERY MATRICES AND STRESS-CORRECTION MATRICESMAIN5110
C     ON TAPE I8                                                      MAIN5120
C-----WRITE UNIT STIFFNESS AND LOAD VECTOR ON TAPE I12                MAIN5130
C*********************************************************************MAIN5140
      IMPLICIT REAL*8 (A-H,O-Z)                                       MAIN5150
      REAL*4 FRC                                                      MAIN5160
      DIMENSION LM(ND),S(ND,ND,NU),P(ND,4,NV),ST(NS,ND,NU),TT(NS,4,NW) MAIN5170
     1,IS(6)                                                          MAIN5180
      COMMON/ELPAR/NPAR(14),NUMNP,MBAND,IELP(17)                      MAIN5190
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                MAIN5200
      MIN=100000                                                      MAIN5210
      MAX=0                                                           MAIN5220
      DO 800 L=1,ND                                                   MAIN5230
      IF (LM(L).EQ.0) GO TO 800                                       MAIN5240
      IF (LM(L).GT.MAX) MAX=LM(L)                                     MAIN5250
      IF (LM(L).LT.MIN) MIN=LM(L)                                     MAIN5260
  800 CONTINUE                                                        MAIN5270
      NDIF=MAX-MIN+1                                                  MAIN5280
      IF (NDIF.GT.MBAND) MBAND=NDIF                                   MAIN5290
      LRD=6+ND*(1+NU*ND)+NV*4)                                        MAIN5300
      IS(1)=NU                                                        MAIN5310
      IS(2)=NW                                                        MAIN5320
      IS(3)=NS                                                        MAIN5330
      IS(4)=ND                                                        MAIN5340
      IS(5)=IDVAR                                                     MAIN5350
      IS(6)=IEX                                                       MAIN5360
      WRITE(I8 ) IS,FRC,LM,ST,TT                                      MAIN5370
      IS(1)=LRD                                                       MAIN5380
      IS(2)=NU                                                        MAIN5390
      IS(3)=NV                                                        MAIN5400
      IS(4)=ND                                                        MAIN5410
      WRITE(I12) IS,FRC,LM,S ,P                                       MAIN5420
      RETURN                                                          MAIN5430
      END                                                             MAIN5440
```

```
      SUBROUTINE REARAN(S,SS,NM1,NM2,NM3,N1,N2,N3,NN)                 MAIN5450
C*********************************************************************MAIN5460
C-----REARRANGE MATRIX S                                              MAIN5470
C*********************************************************************MAIN5480
      IMPLICIT REAL*8 (A-H,O-Z)                                       MAIN5490
      DIMENSION S(NM1,NM2,NM3),SS(NN)                                 MAIN5500
      II=0                                                            MAIN5510
      DO 10 K=1,N3                                                    MAIN5520
      DO 10 J=1,N2                                                    MAIN5530
      DO 11 I=1,N1                                                    MAIN5540
   11 SS(II+I)=S(I,J,K)                                               MAIN5550
   10 II=II+N1                                                        MAIN5560
      RETURN                                                          MAIN5570
      END                                                             MAIN5580
```

```
      SUBROUTINE VECTOR(V,XI,YI,ZI,XJ,YJ,ZJ)                            MAIN5590
C*****************************************************************************MAIN5600
C-----CALCULATE COMPONENTS OF A VECTOR                                   MAIN5610
C*****************************************************************************MAIN5620
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5630
      DIMENSION V(4)                                                    MAIN5640
      X=XJ-XI                                                           MAIN5650
      Y=YJ-YI                                                           MAIN5660
      Z=ZJ-ZI                                                           MAIN5670
      V(4)=DSQRT(X*X+Y*Y+Z*Z)                                           MAIN5680
      V(3)=Z/V(4)                                                       MAIN5690
      V(2)=Y/V(4)                                                       MAIN5700
      V(1)=X/V(4)                                                       MAIN5710
      RETURN                                                            MAIN5720
      END                                                               MAIN5730


      SUBROUTINE CROSS(A,B,C)                                           MAIN5740
C*****************************************************************************MAIN5750
C-----CROSS PRODUCT OF TWO VECTORS                                       MAIN5760
C*****************************************************************************MAIN5770
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5780
      DIMENSION A(4),B(4),C(4)                                          MAIN5790
      X=A(2)*B(3)-A(3)*B(2)                                             MAIN5800
      Y=A(3)*B(1)-A(1)*B(3)                                             MAIN5810
      Z=A(1)*B(2)-A(2)*B(1)                                             MAIN5820
      C(4)=DSQRT(X*X+Y*Y+Z*Z)                                           MAIN5830
      C(3)=Z/C(4)                                                       MAIN5840
      C(2)=Y/C(4)                                                       MAIN5850
      C(1)=X/C(4)                                                       MAIN5860
      RETURN                                                            MAIN5870
      END                                                               MAIN5880


      REAL FUNCTION DOT*8 (A,B)                                         MAIN5890
C*****************************************************************************MAIN5900
C-----DOT PRODUCT OF TWO VECTORS                                         MAIN5910
C*****************************************************************************MAIN5920
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5930
      DIMENSION A(4),B(4)                                               MAIN5940
      DOT=A(1)*B(1)+A(2)*B(2)+A(3)*B(3)                                 MAIN5950
      RETURN                                                            MAIN5960
      END                                                               MAIN5970


      SUBROUTINE ERROR(N)                                               MAIN5980
C*****************************************************************************MAIN5990
C-----PRINT STORAGE EXCEEDED MESSAGE                                     MAIN6000
C*****************************************************************************MAIN6010
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                 MAIN6020
      WRITE (IW,2000) N                                                 MAIN6030
 2000 FORMAT (// 20H STORAGE EXCEEDED BY ,I6)                           MAIN6040
      STOP                                                              MAIN6050
      END                                                               MAIN6060
```

```
      SUBROUTINE INPUTD ( ID, TR, DCON,M,NUMNP,LL,LD,IR,IW,I12)          MAIN6070
C*****************************************************************************MAIN6080
C-----READ DISPLACEMENT CONSTRAINTS AND SET UP DISP. CONSTS. TABLE       MAIN6090
C*****************************************************************************MAIN6100
      DIMENSION ID(NUMNP,6),TR(LL,12),DCON(M)                            MAIN6110
      COMMON/JUNK/ R(12) ,JUNK(288)                                      MAIN6120
      COMMON/EM/ IDD(5066)                                               MAIN6130
      WRITE(IW,3001)                                                     MAIN6140
      LD=0                                                               MAIN6150
      NC=0                                                               MAIN6160
      LRD=0                                                              MAIN6170
      DO 851 I=1,LL                                                      MAIN6180
      DO 851 J=1,12                                                      MAIN6190
  851 TR(I,J)=0.0                                                        MAIN6200
      DO 900 NN=1,NUMNP                                                  MAIN6210
      IF(NN.EQ.1)GO TO 300                                               MAIN6220
  150 IF(N.NE.NN) GO TO 400                                              MAIN6230
      DO 200 I=1,6                                                       MAIN6240
      TR(L,I)= ABS(R(I))                                                 MAIN6250
  200 TR(L,I+6)=-ABS(R(I+6))                                             MAIN6260
      NC=1                                                               MAIN6270
  300 READ(IR,1001)N,L,R                                                 MAIN6280
      GO TO 150                                                          MAIN6290
  400 IF(NC.EQ.0) GO TO 900                                              MAIN6300
      NC=0                                                               MAIN6310
      DO  800 J=1,6                                                      MAIN6320
      DO 70 I=1,LL                                                       MAIN6330
      IF(TR(I,J).NE.0..OR.TR(I,J+6).NE.0) GO TO 80                       MAIN6340
   70 CONTINUE                                                           MAIN6350
      GO TO 810                                                          MAIN6360
   80 II=ID(NN,J)                                                        MAIN6370
      IF(II) 810,810,830                                                 MAIN6380
  830 LD=LD+1                                                            MAIN6390
      IDD(LD)=II                                                         MAIN6400
      DO 30 I=1,LL                                                       MAIN6410
      DCON(LRD+LL+I)=TR(I,J+6)                                           MAIN6420
   30 DCON(LRD+I)=TR(I,J)                                                MAIN6430
      LRD=LRD+2*LL                                                       MAIN6440
      GO TO 800                                                          MAIN6450
  810 DO 815 I=1,LL                                                      MAIN6460
      TR(I,J)=0.                                                         MAIN6470
  815 TR(I,J+6)=0.                                                       MAIN6480
  800 CONTINUE                                                           MAIN6490
      WRITE(IW,2001) (NN,I,(TR(I,J),J=1,12),I=1,LL)                      MAIN6500
      DO 850 I=1,LL                                                      MAIN6510
      DO 850 J=1,12                                                      MAIN6520
  850 TR(I,J)=0.0                                                        MAIN6530
  900 CONTINUE                                                           MAIN6540
      MT=LD*2*LL-M                                                       MAIN6550
      IF(MT.GT.0) CALL ERROR(MT)                                         MAIN6560
      WRITE(I12) (IDD(I),I=1,LD),  (DCON(I),I=1,LRD)                     MAIN6570
      RETURN                                                             MAIN6580
 1001 FORMAT(2I4,12F6.5)                                                 MAIN6590
 2001 FORMAT(1X,2I5,12F10.5)                                             MAIN6600
 3001 FORMAT(//41H  NODAL DISPLACEMENT/ROTATION CONSTRAINTS//            MAIN6610
     1 12H   NODE LOAD ,119H/----------------------------------MAX.ALL.MAIN6620
     2OWABLE DISPLACEMENTS AND ROTATIONS----------------------------MAIN6630
     3-------//,13H   NO.  CASE ,4X,2HDX,8X,2HDY,                      MAIN6640
     48X,2HDZ,8X,2HRX,8X,2HRY,8X,2HRZ,7X,3H-DX,7X,3H-DY,7X,3H-DZ,7X,   MAIN6650
     53H-RX,7X,3H-RY,7X,3H-RZ)                                         MAIN6660
```

```
      END                                                               MAIN6670


      SUBROUTINE INL(ID,TR,B,NUMNP,NEQB,LL,IR,IW,III)                   MAIN6680
C*********************************************************************MAIN6690
C-----INPUT NODAL LOADS                                                 MAIN6700
C*********************************************************************MAIN6710
      REAL*8 B(NEQB,LL)                                                 MAIN6720
      DIMENSION ID(NUMNP,6),TR(6,LL)                                    MAIN6730
      COMMON/JUNK/R(6) ,JUN(294)                                        MAIN6740
      KSHF=0                                                            MAIN6750
      WRITE (IW,2002)                                                   MAIN6760
      DO 750 I=1,NEQB                                                   MAIN6770
      DO 750 K=1,LL                                                     MAIN6780
  750 B(I,K)=0.0                                                        MAIN6790
      DO 900 NN=1,NUMNP                                                 MAIN6800
      DO 100 I=1,6                                                      MAIN6810
      DO 100 J=1,LL                                                     MAIN6820
  100 TR(I,J)=0.0                                                       MAIN6830
      IF(NN.EQ.1) GO TO 300                                             MAIN6840
  150 IF(N.NE.NN) GO TO 400                                             MAIN6850
      DO 200 I=1,6                                                      MAIN6860
  200 TR(I,L)=R(I)                                                      MAIN6870
  300 READ (IR,1001) N,L,R                                              MAIN6880
      IF (N.EQ.0) GO TO 150                                             MAIN6890
      WRITE(IW,2001) N,L,R                                              MAIN6900
      GO TO 150                                                         MAIN6910
  400 DO 800 J=1,6                                                      MAIN6920
      II=ID(NN,J)-KSHF                                                  MAIN6930
      IF (II) 800,800,500                                               MAIN6940
  500 DO 600  K=1,LL                                                    MAIN6950
  600 B(II,K)=TR(J,K)                                                   MAIN6960
  610 IF(II.NE.NEQB) GO TO 800                                          MAIN6970
      WRITE(III) B                                                      MAIN6980
      KSHF=KSHF+NEQB                                                    MAIN6990
      DO 700 I=1,NEQB                                                   MAIN7000
      DO 700 K=1,LL                                                     MAIN7010
  700 B(I,K)=0.0                                                        MAIN7020
  800 CONTINUE                                                          MAIN7030
  900 CONTINUE                                                          MAIN7040
      WRITE(III) B                                                      MAIN7050
      RETURN                                                            MAIN7060
 1001 FORMAT (2I5,7F10.4)                                               MAIN7070
 2001 FORMAT (2I5,6E13.3)                                               MAIN7080
 2002 FORMAT(//18H NODAL POINT LOADS // 10H NODE LOAD,23X     ,         MAIN7090
     . 14HAPPLIED LOADS              / 10H NO. CASE ,9X, 2HRX, 11X,     MAIN7100
     .  2HRY,11X,2HRZ,11X,2HMX,11X,2HMY,11X,2HMZ )                      MAIN7110
      END                                                               MAIN7120
```

```
      SUBROUTINE ELSTIF (AOLD,NUMDV,NUMEL,I1,I2,I11,I12)                MAIN7130
C*****************************************************************************MAIN7140
C-----FORM ELEMENT STIFFNESS FROM UNIT STIFFNESS MATRICES                 MAIN7150
C*****************************************************************************MAIN7160
      IMPLICIT REAL*8 (A-H,O-Z)                                           MAIN7170
      REAL*4 AOLD,FRC                                                     MAIN7180
      DIMENSION AOLD (NUMDV) ,S1(24,24),S2(24,24),P1(24,4),P2(24,4)       MAIN7190
      COMMON/EM/LM(24),S(24,24,2),P(24,4,2),EM1(1177)                     MAIN7200
      EQUIVALENCE (S1,S),(S2,S(577)),(P1,P),(P2,P(97))                    MAIN7210
      REWIND I1                                                           MAIN7220
      REWIND I2                                                           MAIN7230
      REWIND I11                                                          MAIN7240
      REWIND I12                                                          MAIN7250
      READ(I1) AOLD                                                       MAIN7260
      DO 100 N=1,NUMEL                                                    MAIN7270
      READ(I12) LRD,NU,NV,ND,IDVAR,IEX,FRC,(LM(I),I=1,ND),(((S(I,J,K),    MAIN7280
     1 I=1,ND),J=1,ND),K=1,NU),(( P(I,J,K),I=1,ND),J=1,4),K=1,NV)         MAIN7290
      IF(IDVAR.EQ.0) GO TO 106                                            MAIN7300
      AREA=AOLD(IDVAR)**FRC                                               MAIN7310
      XINERT=AREA**IEX                                                    MAIN7320
      DO 101 I=1,ND                                                       MAIN7330
      DO 102 J=1,4                                                        MAIN7340
  102 P1(I,J)=P1(I,J)*AREA                                                MAIN7350
      DO 101 J=1,ND                                                       MAIN7360
  101 S1(I,J)=S1(I,J)*AREA                                                MAIN7370
      IF(NU.EQ.1) GO TO 105                                               MAIN7380
      DO 104 I=1,ND                                                       MAIN7390
      DO 104 J=1,ND                                                       MAIN7400
  104 S1(I,J)=S1(I,J)+S2(I,J)*XINERT                                      MAIN7410
  105 IF(NV.EQ.1) GO TO 106                                               MAIN7420
      DO 107 I=1,ND                                                       MAIN7430
      DO 107 J=1,4                                                        MAIN7440
  107 P1(I,J)=P1(I,J)+P2(I,J)                                             MAIN7450
  106 LRD=ND*(ND+4)                                                       MAIN7460
      NN=ND*ND                                                            MAIN7470
      CALL REARAN(S1,S1,24,24,1,ND,ND,1,NN)                               MAIN7480
      NN=ND*4                                                             MAIN7490
      CALL REARAN(P1,P1,24,4,1,ND,4,1,NN)                                 MAIN7500
      CALL ELSTEW(LRD,ND,LM,S1,P1,I2)                                     MAIN7510
  100 CONTINUE                                                            MAIN7520
C*****************************************************************************MAIN7530
C-----READ  AMIN TO ADVANCE UNIT 111 TO NEXT RECORD : STR                 MAIN7540
C*****************************************************************************MAIN7550
      READ (I11) AOLD                                                     MAIN7560
      RETURN                                                              MAIN7570
      END                                                                 MAIN7580
```

```
      SUBROUTINE ELSTEW(LRD,ND,LM,S1,P1,I2)                               MAIN7590
C*****************************************************************************MAIN7600
C-----WRITE ELEMENT STIFFNESSES ON TAPE I2                                MAIN7610
C*****************************************************************************MAIN7620
      IMPLICIT REAL*8 (A-H,O-Z)                                           MAIN7630
      DIMENSION LM(ND),S1(ND,ND),P1(ND,4)                                 MAIN7640
      WRITE(I2) LRD,ND,LM,S1,P1                                           MAIN7650
      RETURN                                                              MAIN7660
      END                                                                 MAIN7670
```

```
      SUBROUTINE ADDSTF(A,B,STR,NUMEL,NBLOCK,NF2B,LL,MBAND,I2,I9,I10,    MAIN7680
     1 I11)                                                             MAIN7690
C*********************************************************************MAIN7700
C-----FORMS GLOBAL EQUILIBRIUM EQUATIONS IN BLOCKS                      MAIN7710
C*********************************************************************MAIN7720
      REAL*8 A(NF2B,MBAND),B(NF2B,LL) ,SS                               MAIN7730
      DIMENSION STR(4,LL)                                               MAIN7740
      COMMON /FM/ LRD,ND,LM(24),SS(672),FM1(3696)                       MAIN7750
      NEQB=NF2B/2                                                       MAIN7760
      K=NEQB+1                                                          MAIN7770
      X=NBLOCK                                                          MAIN7780
      MB=SQRT(X)                                                        MAIN7790
      MB=MB/2+1                                                         MAIN7800
      NEBB=MB*NF2B                                                      MAIN7810
      MM=1                                                              MAIN7820
      NUM9=0                                                            MAIN7830
      NSHIFT=0                                                          MAIN7840
      REWIND I10                                                        MAIN7850
C*********************************************************************MAIN7860
C-----READ STRUCTURE LOAD MULTIPLIERS                                   MAIN7870
C*********************************************************************MAIN7880
      READ (I11) STR                                                    MAIN7890
C*********************************************************************MAIN7900
C-----FORM EQUATIONS IN BLOCKS  ( TWO BLOCKS AT A TIME )                MAIN7910
C*********************************************************************MAIN7920
      DO 1000 M=1,NBLOCK ,2                                             MAIN7930
      DO 100 I=1,NF2B                                                   MAIN7940
      DO 100 J=1,MBAND                                                  MAIN7950
  100 A(I,J)=0.                                                         MAIN7960
      READ(I11)((B(I,L),I=1,NEQB),L=1,LL)                               MAIN7970
      IF (M.EQ.NBLOCK) GO TO 200                                        MAIN7980
      READ(I11)((B(I,L),I=K,NF2B),L=1,LL)                               MAIN7990
  200 CONTINUE                                                          MAIN8000
      REWIND I9                                                         MAIN8010
      REWIND I2                                                         MAIN8020
      NA=I9                                                             MAIN8030
      NUME=NUM9                                                         MAIN8040
      IF (MM.NE.1) GO TO 75                                             MAIN8050
      NA=I2                                                             MAIN8060
      NUME=NUMEL                                                        MAIN8070
      NUM9=0                                                            MAIN8080
   75 DO 700 N=1,NUME                                                   MAIN8090
      READ (NA) LRD,ND,(LM(I),I=1,ND),(SS(I),I=1,LRD)                   MAIN8100
      DO 600 I=1,ND                                                     MAIN8110
      LMM=1-LM(I)                                                       MAIN8120
      II=LM(I)-NSHIFT                                                   MAIN8130
      IF (II.LE.0.OR.II.GT.NF2B) GO TO 600                              MAIN8140
      DO 300 L=1,LL                                                     MAIN8150
      DO 300 J=1,4                                                      MAIN8160
      KK=ND*(ND+J-1)                                                    MAIN8170
  300 B(II,L)=B(II,L)+SS(I+KK)*STR(J,L)                                 MAIN8180
      DO 500 J=1,ND                                                     MAIN8190
      JJ=LM(J)+LMM                                                      MAIN8200
      IF(JJ) 500,500,390                                                MAIN8210
  390 KK=ND*J-ND                                                        MAIN8220
  400 A(II,JJ)=A(II,JJ)+SS(I+KK)                                        MAIN8230
  500 CONTINUE                                                          MAIN8240
  600 CONTINUE                                                          MAIN8250
C*********************************************************************MAIN8260
C-----DETERMINE IF STIFFNESS IS TO BE PLACED ON UNIT I9                 MAIN8270
```

```
C*******************************************************************************MAIN8280
      IF (MM.GT.1) GO TO 700                                                    MAIN8290
      DO 650 I=1,ND                                                             MAIN8300
      II=LM(I) -NSHIFT                                                          MAIN8310
      IF(II.GT.NE2B.AND.II.LE.NEBB) GO TO 660                                   MAIN8320
  650 CONTINUE                                                                  MAIN8330
      GO TO 700                                                                 MAIN8340
  660 WRITE(19) LRD,ND,(LM(I),I=1,ND),(SS(I),I=1,LRD)                           MAIN8350
      NUM9=NUM9+1                                                               MAIN8360
  700 CONTINUE                                                                  MAIN8370
      WRITE (110)  ((A(I,J),I=1,NEQB),J=1,MBAND),((B(I,L),I=1,NEQB),L=1,MAIN8380
       LL)                                                                      MAIN8390
      IF(M.EQ.NBLOCK) GO TO 1000                                                MAIN8400
      WRITE(110) ((A(I,J),I=K,NE2B),J=1,MBAND),((B(I,L),I=K,NE2B),L=1,LLMAIN8410
     1)                                                                         MAIN8420
      IF (MM.EQ.MB) MM=0                                                        MAIN8430
      MM=MM+1                                                                   MAIN8440
 1000 NSHIFT=NSHIFT+NE2B                                                        MAIN8450
      RETURN                                                                    MAIN8460
      END                                                                       MAIN8470


      SUBROUTINE USOL (MAXB,A,B,NEQB,MB,LL,NBLOCK,NSB,NORG,NRKS,NT1,     MAIN8480
     1 NT2,IW)                                                                  MAIN8490
C*******************************************************************************MAIN8500
C-----THIS SUBPROGRAM SOLVES SIMULTANEOUS EQUATIONS FOR DISPLACEMENTS    MAIN8510
C-----TAPES USED ARE AS FOLLOW                                          MAIN8520
C-----A AND B (TWO BLOCKS OF STRUCTURAL STIFFNESS AND LOAD VECTORS) ARE MAIN8530
C      STORED ON TAPE NORG                                              MAIN8540
C-----SCRATCH ON NRKS , NT1 , NT2                                       MAIN8550
C-----RESULTS ON TAPE NT2                                               MAIN8560
C*******************************************************************************MAIN8570
      DIMENSION MAXB(NEQB)                                                      MAIN8580
      REAL*8 A(NSB),B(NSB)                                                      MAIN8590
      NC=MB+LL                                                                  MAIN8600
      NBR=(MB-1)/NEQB+1                                                         MAIN8610
      INC=NEQB-1                                                                MAIN8620
      NMB=NEQB*MB                                                               MAIN8630
      N2=NT2                                                                    MAIN8640
      N1=NT1                                                                    MAIN8650
      REWIND NORG                                                               MAIN8660
      REWIND NRKS                                                               MAIN8670
C*******************************************************************************MAIN8680
C-----REDUCE EQUATIONS BLOCK-BY-BLOCK                                   MAIN8690
C*******************************************************************************MAIN8700
      DO 900 N=1,NBLOCK                                                         MAIN8710
      IF (N.GT.1.AND.NBR.EQ.1) GO TO 110                                        MAIN8720
      IF (NBR.EQ.1) GO TO 105                                                   MAIN8730
      REWIND N1                                                                 MAIN8740
      REWIND N2                                                                 MAIN8750
  105 N1=N1                                                                     MAIN8760
      IF(N.EQ.1) N1=NORG                                                        MAIN8770
      READ (N1) A                                                               MAIN8780
  110 DO 300 I=1,NEQB                                                           MAIN8790
      D=A(I)                                                                    MAIN8800
      IF(D) 115,300,120                                                         MAIN8810
  115 M=NEQB*(N-1)+I                                                            MAIN8820
      WRITE (IW,116) M,D                                                        MAIN8830
  120 II=I                                                                      MAIN8840
```

```
      DO 125 J=2,NC                                                    MAIN8850
      II=II+NEQB                                                       MAIN8860
  125 A(II)=A(II)/D                                                    MAIN8870
      DO 130 J=I,NMB,NEQB                                              MAIN8880
      IF (A(J).NE.0.) MAXB(I)=J                                        MAIN8890
  130 CONTINUE                                                         MAIN8900
      JL=I+1                                                           MAIN8910
      IF (JL.GT.NEQB) GO TO 300                                        MAIN8920
      II=I                                                             MAIN8930
      DO 200 J=JL,NEQB                                                 MAIN8940
      II=II+NEQB                                                       MAIN8950
      IF(II.GT.NMB) GO TO 200                                          MAIN8960
      C=A(II)                                                          MAIN8970
      IF (C.EQ.0.0) GO TO 200                                          MAIN8980
      C=C*A(I)                                                         MAIN8990
      KK=J-II                                                          MAIN9000
      MAX=MAXB(I)                                                      MAIN9010
      DO 150 JJ=II,MAX,NEQB                                            MAIN9020
  150 A(JJ+KK)=A(JJ+KK)-C*A(JJ)                                        MAIN9030
      KK=J +NMB                                                        MAIN9040
      JJ=I+NMB                                                         MAIN9050
      DO 175 L=1,LL                                                    MAIN9060
      A(KK)=A(KK)-C*A(JJ)                                              MAIN9070
      KK=KK+NEQB                                                       MAIN9080
  175 JJ=JJ+NEQB                                                       MAIN9090
  200 CONTINUE                                                         MAIN9100
  300 CONTINUE                                                         MAIN9110
      WRITE (NBKS) A,MAXB                                              MAIN9120
C***********************************************************************MAIN9130
C-----SUBSTITUTE INTO REMAINING EQUATIONS                              MAIN9140
C***********************************************************************MAIN9150
      DO 800 NN=1,NBR                                                  MAIN9160
      IF(N+NN.GT.NBLOCK) GO TO 800                                     MAIN9170
      NI=N1                                                            MAIN9180
      IF(N.EQ.1) NI=NORG                                               MAIN9190
      IF(NN.EQ.NBR) NI=NORG                                            MAIN9200
      READ (NI) B                                                      MAIN9210
      IL=1+NN*NEQB*NEQB                                                MAIN9220
      DO 700 I=1,NEQB                                                  MAIN9230
      II=IL                                                            MAIN9240
      DO 690 K=1,NEQB                                                  MAIN9250
      IF (II.GT.NMB) GO TO 690                                         MAIN9260
      C=A(II)                                                          MAIN9270
      IF (C.EQ.0.0) GO TO 690                                          MAIN9280
      C=C*A(K)                                                         MAIN9290
      MAX=MAXB(K)                                                      MAIN9300
      KK=I-II                                                          MAIN9310
      DO 640 JJ=II,MAX,NEQB                                            MAIN9320
  640 B(JJ+KK)=B(JJ+KK)-C*A(JJ)                                        MAIN9330
      KK=I+NMB                                                         MAIN9340
      JJ=K+NMB                                                         MAIN9350
      DO 650 L=1,LL                                                    MAIN9360
      B(KK)=B(KK)-C*A(JJ)                                              MAIN9370
      KK=KK+NEQB                                                       MAIN9380
  650 JJ=JJ+NEQB                                                       MAIN9390
  690 II=II-INC                                                        MAIN9400
  700 IL=IL+NEQB                                                       MAIN9410
      IF(NBR.NE.1) GO TO 750                                           MAIN9420
      DO 740 I=1,NSB                                                   MAIN9430
  740 A(I)=B(I)                                                        MAIN9440
```

```
      GO TO 800                                                          MAIN9450
  750 WRITE (N2) B                                                       MAIN9460
  800 CONTINUE                                                           MAIN9470
      M=N1                                                               MAIN9480
      N1=N2                                                              MAIN9490
  900 N2=M                                                               MAIN9500
C*************************************************************************MAIN9510
C-----BACKSUBSTITUTION - RESULTS ON TAPE NT2                             MAIN9520
C*************************************************************************MAIN9530
      LS=LL*NEQB                                                         MAIN9540
      NEB=NEQB*(NBR+1)                                                   MAIN9550
      NUM=NBR*NEQB                                                       MAIN9560
      MAX=NEB*LL                                                         MAIN9570
      DO 905 I=1,MAX                                                     MAIN9580
  905 B(I)=0.                                                            MAIN9590
      REWIND NT2                                                         MAIN9600
      DO 1000 N=1,NBLOCK                                                 MAIN9610
      BACKSPACE NBKS                                                     MAIN9620
      READ (NBKS) A,MAXB                                                 MAIN9630
      BACKSPACE NBKS                                                     MAIN9640
      DO 910 L=1,LL                                                      MAIN9650
      K=L*NEB                                                            MAIN9660
      DO 910 J=1,NUM                                                     MAIN9670
      I=K-NEQB                                                           MAIN9680
      B(K)=B(I)                                                          MAIN9690
  910 K=K-1                                                              MAIN9700
      I=NMB                                                              MAIN9710
      DO 920 L=1,LL                                                      MAIN9720
      K=(L-1)*NEB                                                        MAIN9730
      DO 920 J=1,NEQB                                                    MAIN9740
      I=I+1                                                              MAIN9750
      K=K+1                                                              MAIN9760
  920 B(K)=A(I)                                                          MAIN9770
      DO 955 I=1,NEQB                                                    MAIN9780
      J=NEQB+1-I                                                         MAIN9790
      MAX=MAXB(J)                                                        MAIN9800
      IF (A(J,  0.0,) GO TO 955                                          MAIN9810
      DO 950 L=1,LL                                                      MAIN9820
      KK=J+(L-1)*NEB                                                     MAIN9830
      JJ=KK+1                                                            MAIN9840
      II=J+NEQB                                                          MAIN9850
      C=B(KK)                                                            MAIN9860
      DO 940 II=II,MAX,NEQB                                              MAIN9870
      C=C-A(II)*B(JJ)                                                    MAIN9880
  940 JJ=JJ+1                                                            MAIN9890
  950 B(KK)=C                                                            MAIN9900
  955 CONTINUE                                                           MAIN9910
      I=0                                                                MAIN9920
      DO 960 L=1,LL                                                      MAIN9930
      K=(L-1)*NEB                                                        MAIN9940
      DO 960 J=1,NEQB                                                    MAIN9950
      K=K+1                                                              MAIN9960
      I=I+1                                                              MAIN9970
  960 A(I)=B(K)                                                          MAIN9980
      WRITE(NT2) (A(I),I=1,LS)                                           MAIN9990
 1000 CONTINUE                                                           MAIN0000
      RETURN                                                             MAIN0010
  116 FORMAT (33HOSET OF EQUATIONS MAY BE SINGULAR   /                   MAIN0020
     .  26H DIAGONAL TERM OF EQUATION  ,I8, 8H  EQUALS  ,1PE12.4)        MAIN0030
      END                                                                MAIN0040
```

```
      SUBROUTINE MAXD(IDD,DCON,B,NEQB,LL,LD,NBLOCK,I2,I12,IW,NMAXD)      MAIN0050
C*********************************************************************MAIN0060
C-----CALCULATE MAXIMUM DISPLACEMENT CONSTRAINT RATIOS                  MAIN0070
C*********************************************************************MAIN0080
      DIMENSION IDD(LD),DCON(LL,2,LD)                                   MAIN0090
      REAL*8 B(NEQB,LL)                                                 MAIN0100
      COMMON/JUNK/ML1(4),MF1(4),RM1(4),DC1(4)  ,JUN(284)                MAIN0110
      DO 11 I=1,NMAXD                                                   MAIN0120
   11 RM1(I)=0.0                                                        MAIN0130
      READ(I12) IDD,DCON                                                MAIN0140
      REWIND I2                                                         MAIN0150
      NN=NEQB*NBLOCK                                                    MAIN0160
      LD1=LD                                                            MAIN0170
      DO 500 KK=1,NBLOCK                                                MAIN0180
      READ(I2)B                                                         MAIN0190
      NN=NN-NEQB                                                        MAIN0200
    1 LT=IDD(LD1)                                                       MAIN0210
      IF(LT.LE.NN) GO TO 500                                            MAIN0220
      LTN=LT-NN                                                         MAIN0230
C*********************************************************************MAIN0240
C-----CALCULATE ACTUAL DISPLACEMENT TO CONSTRAINED DISPLACEMENT RATIO   MAIN0250
C     FOR ALL LOAD CONDITIONS                                           MAIN0260
C*********************************************************************MAIN0270
      DO 10 J=1,LL                                                      MAIN0280
      RATIO=0.0                                                         MAIN0290
      BB=B(LTN,J)                                                       MAIN0300
      IF(BB) 20,10,30                                                   MAIN0310
   30 DD=DCON(J,1,LD1)                                                  MAIN0320
      IF(DD.EQ.0) GO TO 10                                              MAIN0330
      GO TO 50                                                          MAIN0340
   20 DD=-DCON(J,2,LD1)                                                 MAIN0350
      IF(DD.EQ.0) GO TO 10                                              MAIN0360
   50 RATIO=BB/DD                                                       MAIN0370
      ARATIO=ABS(RATIO)                                                 MAIN0380
C*********************************************************************MAIN0390
C-----FIND THE MIN. RATIO OF FOUR MAX. DISP. RATIOS FOUND SO FAR        MAIN0400
C*********************************************************************MAIN0410
      R=1.0E20                                                          MAIN0420
      J1=0                                                              MAIN0430
      DO 70 JJ=1,NMAXD                                                  MAIN0440
      RT=ABS(RM1(JJ))                                                   MAIN0450
      IF(RT.GE.R) GO TO 70                                              MAIN0460
      R=RT                                                              MAIN0470
      J1=JJ                                                             MAIN0480
   70 CONTINUE                                                          MAIN0490
C*********************************************************************MAIN0500
C-----REPLACE THIS MIN.RATIO WITH NEW RATIO IF IT IS GREATER            MAIN0510
C*********************************************************************MAIN0520
      IF(ARATIO.LE.R) GO TO 10                                          MAIN0530
      RM1(J1)=RATIO                                                     MAIN0540
      MF1(J1)=LT                                                        MAIN0550
      ML1(J1)=J                                                         MAIN0560
      DC1(J1)=DD                                                        MAIN0570
   10 CONTINUE                                                          MAIN0580
      LD1= LD1-1                                                        MAIN0590
      IF(LD1.EQ.0) GO TO 100                                            MAIN0600
      GO TO 1                                                           MAIN0610
  500 CONTINUE                                                          MAIN0620
  100 RETURN                                                            MAIN0630
      END                                                               MAIN0640
```

```
      SUBROUTINE PRINTD(ID,D,B,NEQB,NUMNP,LL,NBLOCK,NEQ,I2,I8,IW,KP)    MAIN0650
C*********************************************************************MAIN0660
C-----PRINT NODAL DISPLACEMENTS                                        MAIN0670
C*********************************************************************MAIN0680
      DIMENSION ID(NUMNP,6),D(6,LL)                                     MAIN0690
      REAL*8 B(NEQB,LL)                                                 MAIN0700
      REWIND I8                                                         MAIN0710
      READ (I8) ID                                                      MAIN0720
      IF(KP.EQ.0) RETURN                                                MAIN0730
      REWIND I2                                                         MAIN0740
      M=NEQ                                                             MAIN0750
      NN=NEQB*NBLOCK                                                    MAIN0760
      N=NUMNP                                                           MAIN0770
      WRITE(IW,2003)                                                    MAIN0780
      DO 500 KK=1,NUMNP                                                 MAIN0790
      I=6                                                               MAIN0800
      DO 250 II=1,6                                                     MAIN0810
      DO 100 L=1,LL                                                     MAIN0820
  100 D(I,L)=0.                                                         MAIN0830
      IF(M.GT.NN) GO TO 150                                             MAIN0840
      IF (M.EQ.0) GO TO 150                                             MAIN0850
      READ(I2) B                                                        MAIN0860
      NN=NN-NEQB                                                        MAIN0870
  150 IF(ID(N,I).LT.1) GO TO 250                                        MAIN0880
      K=M-NN                                                            MAIN0890
      M=M-1                                                             MAIN0900
      DO 200 L=1,LL                                                     MAIN0910
  200 D(I,L)=B(K,L)                                                     MAIN0920
  250 I=I-1                                                             MAIN0930
      WRITE(IW,2004) N,(L,(D(I,L),I=1,6),L=1,LL)                        MAIN0940
  500 N=N-1                                                             MAIN0950
      RETURN                                                            MAIN0960
 2003 FORMAT (34H NODAL DISPLACEMENTS AND ROTATIONS//                   MAIN0970
     .  5H NODE ,5H LOAD ,11X ,1HX ,11X ,1HY ,11X ,1HZ ,10X ,2HXX,      MAIN0980
     . 10X ,2HYY ,10X ,2HZZ//)                                          MAIN0990
 2004 FORMAT (1H ,I4,I5,1P3E12.3,3E12.4/(I10,3E12.3,3E12.4))            MAIN1000
      END                                                               MAIN1010
```

```
      SUBROUTINE OPRINT (A,NV,IW)                                       MAIN1020
C*********************************************************************MAIN1030
C-----PRINT DESIGN VARIABLE ARRAY                                      MAIN1040
C*********************************************************************MAIN1050
      DIMENSION A(NV)                                                   MAIN1060
      WRITE(IW,1006)                                                    MAIN1070
      NROW=(NV-1)/10+1                                                  MAIN1080
      DO 220 N=1,NROW                                                   MAIN1090
      M=(N-1)*10                                                        MAIN1100
      ISTART=M+1                                                        MAIN1110
      ISTOP=M+10                                                        MAIN1120
      IF(ISTOP.GT.NV) ISTOP=NV                                          MAIN1130
  220 WRITE(IW,1007) M,(A(I),I=ISTART,ISTOP)                            MAIN1140
      RETURN                                                            MAIN1150
 1006 FORMAT(//28H VALUES OF DESIGN VARIABLES //                        MAIN1160
     1125H          1          2          3          4          5 MAIN1170
     2          6          7          8          9         10     / )MAIN1180
 1007 FORMAT(1H ,I5,10F12.4)                                            MAIN1190
      END .                                                             MAIN1200
```

```
      SUBROUTINE STRESS(AOLD,ASTR,LOAD,STR,B,D,LL,LB,NEQ,NUMDV,NEQB     MAIN1210
     1 ,A,MTOT,I1,I2,IB,III,IW)                                         MAIN1220
C*********************************************************************MAIN1230
C-----CALCULATE STRESSES                                               MAIN1240
C*********************************************************************MAIN1250
      DIMENSION STR(4,LL),D(NEQ,LB),LOAD(NUMDV),AOLD(NUMDV),ASTR(NUMDV) MAIN1260
     1 ,A(MTOT)                                                         MAIN1270
      REAL*8 B(NEQB,LL)                                                 MAIN1280
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,   MAIN1290
     1 ELP(9),NBLOCK                                                    MAIN1300
      COMMON/JUNK/JUN(16),LT,LH ,JUN1(282)                              MAIN1310
      REWIND I1                                                         MAIN1320
      REWIND III                                                        MAIN1330
      READ (I1) AOLD                                                    MAIN1340
      READ(III) ASTR                                                    MAIN1350
C*********************************************************************MAIN1360
C-----PRINT DESIGN VARIABLE ARRAY FOR CURRENT DESIGN                   MAIN1370
C*********************************************************************MAIN1380
      CALL DPRINT (AOLD,NUMDV,IW)                                       MAIN1390
      DO 111 I=1,NUMDV                                                  MAIN1400
  111 LOAD(I)=0                                                         MAIN1410
      READ (III) STR                                                    MAIN1420
      NT=(LL-1)/LB +1                                                   MAIN1430
      LH=0                                                              MAIN1440
      DO 1000 II=1,NT                                                   MAIN1450
C*********************************************************************MAIN1460
C-----MOVE DISPLACEMENTS INTO CORE FOR LB LOAD CONDITIONS               MAIN1470
C*********************************************************************MAIN1480
      CALL MOVED(B,D,NEQB,NBLOCK,NEQ,LL,LB,LH,LT,I2)                    MAIN1490
C*********************************************************************MAIN1500
C-----CALCULATE ELEMENT STRESSES AND PERFORM FULLY STRESSED  DESIGN     MAIN1510
C     FOR LB LOAD CONDITIONS                                            MAIN1520
C*********************************************************************MAIN1530
      DO 1000 M=1,NELTYP                                                MAIN1540
      READ (I8) NPAR                                                    MAIN1550
      MTYPE=NPAR(1)                                                     MAIN1560
      NPAR(1)=0                                                         MAIN1570
      CALL ELTYPE (A,MTOT,MTYPE,IW)                                     MAIN1580
 1000 CONTINUE                                                          MAIN1590
      RETURN                                                            MAIN1600
      END                                                               MAIN1610
```

```
      SUBROUTINE MOVED(B,D,NEQB,NBLOCK,NEQ,LL,LB,LH,LT,I2)              MAIN1620
C*********************************************************************MAIN1630
C-----MOVE DISPLACEMENTS INTO CORE FOR LB LOAD CONDITIONS FROM TAPE NT  MAIN1640
C*********************************************************************MAIN1650
      DIMENSION D(NEQ,LB)                                               MAIN1660
      REAL*8 B(NEQB,LL)                                                 MAIN1670
      REWIND I2                                                         MAIN1680
      LT=LH+1                                                           MAIN1690
      LLT=1-LT                                                          MAIN1700
      LH=LT+LB-1                                                        MAIN1710
      IF(LH.GT.LL ) LH=LL                                               MAIN1720
      NQ=NEQB*NBLOCK                                                    MAIN1730
      DO 200 NN=1,NBLOCK                                                MAIN1740
      READ(I2) B                                                        MAIN1750
```

```
      N=NEQB                                                            MAIN1760
      IF (NN.EQ.1) N=NEQ-NQ+NEQB                                        MAIN1770
      NQ=NQ-NEQB                                                        MAIN1780
      DO 200 J=1,N                                                      MAIN1790
      I=NQ+J                                                            MAIN1800
      DO 200 L=LT,LH                                                    MAIN1810
      K=L+LT                                                            MAIN1820
  200 D(I,K)=B(J,L)                                                     MAIN1830
      RETURN                                                            MAIN1840
      END                                                               MAIN1850



      SUBROUTINE STRSC (ADLD,STR,D,NEQ,NUMDV,LL,LB,IB,NTAG        )    MAIN1860
C*********************************************************************MAIN1870
C-----SET UP STRESS MATRIX AND CALCULATE STRESSES                       MAIN1880
C*********************************************************************MAIN1890
      REAL*8 P1,P2,ST1,ST2,ST,P                                         MAIN1900
      DIMENSION STR(4,LL),D(NEQ,LB),ADLD(NUMDV),P1(15,4),P2(15,4),      MAIN1910
     1 ST1(15,24),ST2(15,24)                                            MAIN1920
      COMMON/JUNK/JUN(16),LT,LH,L,SG(27),IDVAR,IFX,FRC,AREA,XINERT,     MAIN1930
     1 DESINE(249)                                                      MAIN1940
      COMMON/EM/NU,NW,NS,ND,LM(24),ST(15,24,2),P(15,4,2),EM1(3358)      MAIN1950
      EQUIVALENCE (P1,P),(P2,P(61)),(ST,ST1),(ST(361),ST2)              MAIN1960
      IF (NTAG.EQ.0) GO TO 800                                          MAIN1970
      NL=L-LT+1                                                         MAIN1980
      DO 300 I=1,NS                                                     MAIN1990
      SG(I)=0.0                                                         MAIN2000
      DO 300 J=1,4                                                      MAIN2010
  300 SG(I)=SG(I)+P1(I,J)*STR(J,L)                                      MAIN2020
      DO 500 J=1,ND                                                     MAIN2030
      JJ=LM(J)                                                          MAIN2040
      IF(JJ.EQ.0) GO TO 500                                             MAIN2050
      DO 400 I=1,NS                                                     MAIN2060
  400 SG(I)=SG(I)+ST1(I,J)*D(JJ,NL)                                     MAIN2070
  500 CONTINUE                                                          MAIN2080
      GO TO 110                                                         MAIN2090
  800 READ(18) NU,NW,NS,ND,IDVAR,IFX,FRC,(LM(I),I=1,ND),(((ST(I,J,K),   MAIN2100
     1 I=1,NS),J=1,ND),K=1,NU),(((P(I,J,K),I=1,NS),J=1,4),K=1,NW)       MAIN2110
      IF(IDVAR.EQ.0) GO TO 110                                          MAIN2120
      AREA= ADLD(IDVAR)*FRC                                             MAIN2130
      XINERT=AREA**IFX                                                  MAIN2140
      DO 100 I=1,NS                                                     MAIN2150
      DO 101 J=1,4                                                      MAIN2160
  101 P1(I,J)=P1(I,J)*AREA                                              MAIN2170
      DO 100 J=1,ND                                                     MAIN2180
  100 ST1(I,J)=ST1(I,J)*AREA                                            MAIN2190
      READ(18) NI,(DESINE(I),I=1,NI)                                    MAIN2200
      IF (NU.EQ.1) GO TO 900                                            MAIN2210
      DO 104 I=1,NS                                                     MAIN2220
      DO 104 J=1,ND                                                     MAIN2230
  104 ST1(I,J)=ST1(I,J)+ST2(I,J)*XINERT                                 MAIN2240
  900 IF(NW.EQ.1) GO TO 110                                             MAIN2250
      DO 105 I=1,NS                                                     MAIN2260
      DO 105 J=1,4                                                      MAIN2270
  105 P1(I,J)=P1(I,J)+P2(I,J)                                           MAIN2280
  110 RETURN                                                            MAIN2290
      END                                                               MAIN2300
```

```
      SUBROUTINE DESIGN(AOLD,ASTR,LOAD,UWT,NUMDV,I1,I8,I11,IW,IP)       MAIN2310
C*************************************************************************MAIN2320
C-----EVALUATE THE CURRENT DESIGN AND PERFORM REDESIGN OPERATION         MAIN2330
C*************************************************************************MAIN2340
      DIMENSION AOLD(NUMDV),ASTR(NUMDV),LOAD(NUMDV),UWT(NUMDV)          MAIN2350
      COMMON/CONTR/ICYCL,NCYCL,ISCALE,NSCALE,KONVG,IDESN,IWTMIN,        MAIN2360
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,KDISP,NMAXD,NDISP,LB1,ALPA,SF,IS.MAIN2370
     1 SMAX,DMAX,CONST                                                  MAIN2380
      COMMON/JUNK/ML1(4),ME1(4),DRAT(4),DCON(4) ,JUN(284)               MAIN2390
      READ(I8) UWT                                                      MAIN2400
      KONVG=1                                                           MAIN2410
      SMAX=0.                                                           MAIN2420
      SMIN=1.0E20                                                       MAIN2430
      DMAX=0.                                                           MAIN2440
      NDISP=0                                                           MAIN2450
      IS=0                                                              MAIN2460
      WT=0.                                                             MAIN2470
      RCONST=2.0                                                        MAIN2480
      DO 221 I=1,NUMDV                                                  MAIN2490
  221 WT=WT+AOLD(I)*UWT(I)                                              MAIN2500
C*************************************************************************MAIN2510
C-----COMPUTE MAX. AND MIN. STRESS RATIOS AND PRINT  THEM               MAIN2520
C*************************************************************************MAIN2530
      DO 68 I=1,NUMDV                                                   MAIN2540
      R=ASTR(I)/AOLD(I)                                                 MAIN2550
      IF(R.LE.SMAX) GO TO 69                                            MAIN2560
      SMAX=R                                                            MAIN2570
      IMAX=I                                                            MAIN2580
      LMAX=LOAD(I)                                                      MAIN2590
   69 IF(R.GE.SMIN) GO TO 68                                            MAIN2600
      SMIN=R                                                            MAIN2610
      IMIN=I                                                            MAIN2620
      LMIN=LOAD(I)                                                      MAIN2630
   68 CONTINUE                                                          MAIN2640
      WRITE(IW,1000)IDESN,SMAX,LMAX,IMAX,SMIN,LMIN,IMIN                 MAIN2650
       IF(KDISP.EQ.0)GO TO 80                                           MAIN2660
C*************************************************************************MAIN2670
C-----PRINT DISPLACEMENT CONSTRAINT RATIOS                              MAIN2680
C*************************************************************************MAIN2690
      WRITE(IW,2002)                                                    MAIN2700
      DO 79 I=1,NMAXD                                                   MAIN2710
      IF(DRAT(I).NE.0) WRITE(IW,2001)DRAT(I),ML1(I),ME1(I)              MAIN2720
   79 CONTINUE                                                          MAIN2730
C*************************************************************************MAIN2740
C-----CALCULATE NO. OF POSSIBLE ACTIVE DISPLACEMENT CONSTRAINTS         MAIN2750
C-----ZERO OUT DISPLCEMENT RATIOS WHICH ARE NOT LIKELY TO BE ACTIVE     MAIN2760
C-----FIND MAX. DISPLACEMENT RATIO                                      MAIN2770
C*************************************************************************MAIN2780
      DO 70 I=1,NMAXD                                                   MAIN2790
      ABD=ABS(DRAT(I))                                                  MAIN2800
      IF(KSCALE.GT.0) ABD =(ABD )**(1.0/KSCALE)                         MAIN2810
      R=ABD/SMAX                                                        MAIN2820
      IF(R.LT.CONST) GO TO 71                                           MAIN2830
      NDISP=NDISP+1                                                     MAIN2840
      IF(ABD.GT.DMAX) DMAX=ABD                                          MAIN2850
      GO TO 70                                                          MAIN2860
   71 DRAT(I)=0.                                                        MAIN2870
   70 CONTINUE                                                          MAIN2880
   80 SF=SMAX                                                           MAIN2890
      IF(SF.LT.DMAX) SF=DMAX                                            MAIN2900
```

```
      IF(SF.LT.DELTA1.OR.SF.GT.DELTA2) GO TO 305                        MAIN2910
      IF(SMIN.LT.DELTA1.OR.SMIN.GT.DELTA2) GO TO 83                     MAIN2920
      WRITE(IW,1004)                                                    MAIN2930
      KONVG=4                                                           MAIN2940
      WRITE(IW,1008) WT                                                 MAIN2950
      GO TO 85                                                          MAIN2960
   83 WRITE(IW,1003)                                                    MAIN2970
      WRITE(IW,1008) WT                                                 MAIN2980
   84 WRITE(IW,2005)                                                    MAIN2990
      KONVG=3                                                           MAIN3000
      IF(DMAX.GT.SMAX) KONVG=2                                          MAIN3010
      ISCALE=0                                                          MAIN3020
      ICYCL=ICYCL+1                                                     MAIN3030
      IF(ICYCL.LE.NCYCL) GO TO 85                                       MAIN3040
      KONVG=4                                                           MAIN3050
      WRITE(IW,1005) NCYCL                                              MAIN3060
      GO TO 85                                                          MAIN3070
  305 IF(KSCALE.GE.0 .AND. SF.LT.RCONST) GO TO 101                      MAIN3080
      WRITE(IW,1002)                                                    MAIN3090
      GO TO 84                                                          MAIN3100
  101 IS=1                                                              MAIN3110
      IF(KSCALE.LE.0) SF=SMAX                                           MAIN3120
      DO 103 I=1,NUMDV                                                  MAIN3130
  103 ADLD(I)=ADLD(I)*SF                                                MAIN3140
      IF(KSCALE.LE.0) GO TO 803                                         MAIN3150
      WRITE(IW,2004)                                                    MAIN3160
      CALL MESG(SMAX,DMAX,SF,IW)                                        MAIN3170
      WRITE(IW,2006)                                                    MAIN3180
      CALL DPRINT (ADLD,NUMDV,IW)                                       MAIN3190
      WT=WT*SF                                                          MAIN3200
      WRITE(IW,1008) WT                                                 MAIN3210
      GO TO 84                                                          MAIN3220
  803 WRITE(IW,1002)                                                    MAIN3230
      WRITE(IW,2004)                                                    MAIN3240
      ISCALE=ISCALE+1                                                   MAIN3250
      IF(ISCALE.EQ.NSCALE) GO TO 203                                    MAIN3260
      IF(NDISP.NE.0) RETURN                                             MAIN3270
      REWIND 11                                                         MAIN3280
      WRITE(11) ADLD                                                    MAIN3290
      CALL MESG(SMAX,SMAX,SMAX,IW)                                      MAIN3300
      RETURN                                                            MAIN3310
  203 KONVG=4                                                           MAIN3320
      WRITE(IW,1001) NSCALE                                             MAIN3330
   85 IF(KONVG.EQ.4) GO TO 501                                          MAIN3340
      IF(KSCALE.LT.0 .OR.SF.GE.2.0) GO TO 503                           MAIN3350
      IF(WT.LT.WTMIN) GO TO 502                                         MAIN3360
      R=(WT-WTMIN)/WTMIN                                                MAIN3370
      IF(R.LT.EPSIL) GO TO 503                                          MAIN3380
      KONVG=4                                                           MAIN3390
      WRITE(IW,1009) IWTMIN                                             MAIN3400
      GO TO 501                                                         MAIN3410
  502 WTMIN=WT                                                          MAIN3420
      IWTMIN=IDESN                                                      MAIN3430
  503 IF(NDISP.EQ.0) REWIND 11                                          MAIN3440
      WRITE(11) ASTR                                                    MAIN3450
      RETURN                                                            MAIN3460
  501 IF(KPUNCH.NE.1) RETURN                                            MAIN3470
      REWIND 111                                                        MAIN3480
      READ(111) ASTR                                                    MAIN3490
      DO 250 I=1,NUMDV                                                  MAIN3500
```

```
  250 WRITE(JP,1010) I,APLD(I),ASTR(I)                                  MAIN3510
      RETURN                                                            MAIN3520
 1000 FORMAT (// 32H ********************************/                  MAIN3530
     1           28H EVALUATION OF DESIGN NUMBER,I4  /                  MAIN3540
     2            32H ********************************///               MAIN3550
     350H          STRESS RATIO   LOAD COND   DES VARIABLE/,            MAIN3560
     4 4H MAX,F18.4,I10,I13,                          /                 MAIN3570
     5  4H MIN,F18.4,I10,I13                        / )                 MAIN3580
 1001 FORMAT(49H TERMINAL DESIGN---NUMBER OF SCALING OPERATIONS= ,I4//) MAIN3590
 1002 FORMAT(//23H DESIGN IS NOT CRITICAL//)                            MAIN3600
 1003 FORMAT(//23H DESIGN IS CRITICAL    //)                            MAIN3610
 1004 FORMAT(//23H DESIGN IS ACCEPTABLE  //)                            MAIN3620
 1005 FORMAT(//48H TERMINAL DESIGN---NUMBER OF CRITICAL DESIGNS  =,I5//)MAIN3630
 1008 FORMAT(//19H STRUCTURAL WEIGHT=,E11.4)                            MAIN3640
 1009   FORMAT(60H TERMINAL DESIGN---LIGHTEST CRITICAL DESIGN IS DESIGN MAIN3650
     1NUMBER,I4//)                                                      MAIN3660
 1010 FORMAT(I5,2F10.5)                                                 MAIN3670
 2001 FORMAT(7X,F13.4,2I10)                                             MAIN3680
 2002 FORMAT(48H       MAX DISP RATIOS    LOAD COND   FEM NUMBER/ )     MAIN3690
 2004 FORMAT(//1X,33HUNIFORM SCALING OPERATION FOLLOWS)                 MAIN3700
 2005 FORMAT(//1X,26HREDESIGN OPERATION FOLLOWS)                        MAIN3710
 2006 FORMAT(//1X,48HDESIGN VARIABLES OF SCALED (CRITICAL) DESIGN ARE)  MAIN3720
      END                                                               MAIN3730
```

```
      SUBROUTINE MESG(SF,DF,SFF,IW)                                     MAIN3740
C*************************************************************************MAIN3750
C-----PRINT SCALE FACTOR FOR DESIGN SCALING                             MAIN3760
C*************************************************************************MAIN3770
      IF(SF.GE.DF) GO TO 550                                            MAIN3780
      WRITE(IW,1003) SFF                                                MAIN3790
      WRITE(IW,1004)                                                    MAIN3800
      GO TO 551                                                         MAIN3810
  550 WRITE(IW,1003) SF                                                 MAIN3820
      WRITE(IW,1005)                                                    MAIN3830
  551 RETURN                                                            MAIN3840
 1003 FORMAT(//1X,15HSCALE FACTOR IS,F7.3,17HAND DETERMINED BY)         MAIN3850
 1004 FORMAT(1H+,40X,24HDISPLACEMENT CONSTRAINTS)                       MAIN3860
 1005 FORMAT(1H+,40X,18HSTRESS CONSTRAINTS)                             MAIN3870
      END                                                               MAIN3880
```

```
      SUBROUTINE DDERV (A,AD,MTOT,MTOT2,NBOUND)                          MAIN3890
C*********************************************************************MAIN3900
C-----CALCULATE DISPLACEMENT DERIVATIVES                                 MAIN3910
C*********************************************************************MAIN3920
      COMMON/ELPAR/NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTTT,NEQ   MAIN3930
     1,NUMEL,NUMDV,M1,M2,M3,LL,LB,NEQB,NBLOCK                            MAIN3940
      COMMON/JUNK/JUNK1(16),JUNK2(16),JUNK3(268)                         MAIN3950
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                  MAIN3960
      COMMON/CONTR/ ICYCL,NCYCL,ISCALE,NSCALE,KSCALE,KONVG,IDESN,IWTMIN,MAIN3970
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,KDISP,NMAXD,NDISP,LB1,ALPA,SF,IS,MAIN3980
     1 SMAX,DMAX,OMEGA                                                   MAIN3990
      DIMENSION A(MTOT)                                                  MAIN4000
      REAL*8 AD(MTOT2)                                                   MAIN4010
      DO 10 I=1,16                                                       MAIN4020
   10 JUNK2(I)=0                                                         MAIN4030
C*********************************************************************MAIN4040
C-----REARRANGE ACTUAL DISPLACEMENTS AND DISP. CONSTRAINT RATIOS         MAIN4050
C-----A(I) ,I=1,,NUMDV IS ADLD CARRIED FROM STRESS,AND DESIGN SUBROUTINEMAIN4060
C*********************************************************************MAIN4070
      LB1=(MTOT-NEQB*LL*2-NUMDV)/NEQ                                     MAIN4080
      IF(LB1.GT.LL)LB1=LL                                                MAIN4090
      M1=1                                                               MAIN4100
      M2=M1+NUMDV                                                        MAIN4110
      M3=M2+NEQ*LB1                                                      MAIN4120
      MD3=M3/2+1                                                         MAIN4130
      CALL ARRAN(A(M2),AD(MD3),LB1,LL,NEQB,NBLOCK,NEQ,NMAXD,I2,I3)       MAIN4140
C*********************************************************************MAIN4150
C-----CALCULATE THE PRODUCT U(ACTUAL) TRANSPOSE* STIFFNESS MATRIX DER.  MAIN4160
C*********************************************************************MAIN4170
      LB1=(MTOT-NEQB*NDISP*2)/(NUMDV+NEQ)                                MAIN4180
      IF(LB1.GE.1) GO TO 25                                              MAIN4190
      MM=NEQB*NDISP*2+NEQ+NUMDV-MTOT                                     MAIN4200
      CALL ERROR(MM)                                                     MAIN4210
   25 IF(LB1.GT.NDISP)LB1=NDISP                                          MAIN4220
      CALL FORCES(A(N1),A(N2),LB1,NEQ,NDISP,NUMEL,NUMDV,I1,I3,I12)       MAIN4230
C*********************************************************************MAIN4240
C-----INPUT DUMMY LOADS                                                  MAIN4250
C*********************************************************************MAIN4260
      ND2=N1+NEQB*MBAND                                                  MAIN4270
      CALL DUMAN(AD(N1),AD(ND2),AD(ND2),NEQB,MBAND,NBLOCK,LL,NDISP,I2,   MAIN4280
     1I10)                                                               MAIN4290
C*********************************************************************MAIN4300
C-----CALCULATE DUMMY DISPLACEMENTS                                      MAIN4310
C*********************************************************************MAIN4320
      NSB=(MBAND+NDISP)*NEQB                                             MAIN4330
      N2=N1+NEQB                                                         MAIN4340
      ND2=N2/2+1                                                         MAIN4350
      ND3=ND2+NSB                                                        MAIN4360
      CALL USOL(A(N1),AD(ND2),AD(ND3),NEQB,MBAND,NDISP,NBLOCK,NSB        MAIN4370
     . ,I2,I3,I9,I10,IW)                                                 MAIN4380
C*********************************************************************MAIN4390
C-----CALCULATE DERIVATIVES                                              MAIN4400
C*********************************************************************MAIN4410
      N2=N1+NUMDV*LB1                                                    MAIN4420
      N3=N2+NEQ*LB1                                                      MAIN4430
      MD3=M3/2+1                                                         MAIN4440
C*********************************************************************MAIN4450
C-----READ ADLD AND/OR ASTR TO ADVANCE FILE 1                            MAIN4460
C*********************************************************************MAIN4470
      REWIND I1                                                          MAIN4480
```

```
      READ(I1) (A(I),I=1,NUMDV)                                          MAIN4490
      IF(KONVG.NE.1) READ(I1) (A(I),I=1,NUMDV)                           MAIN4500
      NUME=NUMEL-NROUND                                                  MAIN4510
      CALL DERV(A(N1),A(N2),A(N03),NDISP,LB1,NUMDV,NEQ,NEQR,NBLOCK,      MAIN4520
     1NUME ,I1,I3,I10,I11)                                               MAIN4530
      RETURN                                                             MAIN4540
      END                                                                MAIN4550



      SUBROUTINE ARRAN(D,B,LB1,LL,NEQR,NBLOCK,NEQ,NMAXD,I2,I3)           MAIN4560
C*********************************************************************MAIN4570
C-----REARRANGE ACTUAL DISPLACEMENTS WHICH ARE ON TAPE I2               MAIN4580
C*********************************************************************MAIN4590
      DIMENSION D(NEQ,LB1)                                               MAIN4600
      REAL*8 B(NEQR,LL)                                                  MAIN4610
      COMMON/JUNK/ML(4),MF(4),RM(4),DC(4),MLC(4),MEQ(4),DRAT(4),DCON(4),MAIN4620
     1 JUN(268)                                                          MAIN4630
      NT=(LL-1)/LB1+1                                                    MAIN4640
      LH=0                                                               MAIN4650
      L=0                                                                MAIN4660
      REWIND I3                                                          MAIN4670
      DO 10 I=1,NT                                                       MAIN4680
      CALL MOVED(B,D,NEQR,NBLOCK,NEQ,LL,LB1,LH,L1,I2)                    MAIN4690
C*********************************************************************MAIN4700
C-----WRITE THE DISPLACEMENTS FOR MAX. RATIOS ON TAPE I3                MAIN4710
C-----REARRANGE MAX. DISPLACEMENT RATIOS IN INCREASING ORDER OF LOAD     MAIN4720
C     CONDITION NUMBERS                                                  MAIN4730
C*********************************************************************MAIN4740
      DO 10 J=L,LH                                                       MAIN4750
      DO 10 K=1,NMAXD                                                    MAIN4760
      IF(RM(K).EQ.0) GO TO 10                                            MAIN4770
      KK=ML(K)                                                           MAIN4780
      IF(KK.NE.J) GO TO 10                                               MAIN4790
      WRITE(I3) (D(M,KK),M=1,NEQ)                                        MAIN4800
      L=L+1                                                              MAIN4810
      MLC(L)=ML(K)                                                       MAIN4820
      MEQ(L)=MF(K)                                                       MAIN4830
      DRAT(L)=RM(K)                                                      MAIN4840
      DCON(L)=DC(K)                                                      MAIN4850
   10 CONTINUE                                                           MAIN4860
      RETURN                                                             MAIN4870
      END                                                                MAIN4880
```

```
      SUBROUTINE FORCES(ADLD,D,LB1,NEQ,NDISP,NUMEL,NUMDV,I1,I3,I12)     MAIN4890
C*************************************************************************MAIN4900
C-----CALCULATE THE INTERMEDIATE PRODUCT U(I) TRANSPOSE*                  MAIN4910
C     (STIFFNESS MATRIX DERIVATIVE) IN CALCULATING DEFLECTION CONSTRAINT  MAIN4920
C     DERIVATIVES                                                         MAIN4930
C*************************************************************************MAIN4940
      REAL*8 S,P,S1,S2                                                    MAIN4950
      DIMENSION ADLD(NUMDV),D(NEQ,LB1),S1(24,24),S2(24,24)                MAIN4960
      COMMON/EM/LM(24),S(24,24,2),P(24,4,2),EM(2354)                      MAIN4970
      COMMON/JUNK/JUN(32),C(4,24) ,JUN1(172)                              MAIN4980
      EQUIVALENCE (S1,S),(S2,S(577))                                      MAIN4990
      REWIND I3                                                           MAIN5000
      L1=LB1                                                              MAIN5010
      NT=(NDISP-1)/LB1+1                                                  MAIN5020
      DO 100 II=1,NT                                                      MAIN5030
C*************************************************************************MAIN5040
C-----READ ACTUAL DISPLACEMENT FOR LB  LOAD CONDITIONS                    MAIN5050
C*************************************************************************MAIN5060
      LT=II*LB1                                                           MAIN5070
      IF(LT.GT.NDISP)L1=NDISP-LT+LB1                                      MAIN5080
      DO 200 L=1,L1                                                       MAIN5090
  200 READ(I3) (D(I,L),I=1,NEQ)                                           MAIN5100
      REWIND I12                                                          MAIN5110
      DO 100  NN=1,NUMEL                                                  MAIN5120
C*************************************************************************MAIN5130
C-----READ ELEMENT INFORMATION                                            MAIN5140
C*************************************************************************MAIN5150
      READ(I12) LRD,NU,NV,ND,IDVAR,IFX,FRC,(LM(I),I=1,ND),(((S(I,J,K),    MAIN5160
     1 I=1,ND),J=1,ND),K=1,NU),(((P(I,J,K),I=1,ND),J=1,4),K=1,NV)         MAIN5170
      IF(IDVAR.LE.0) GO TO 100                                            MAIN5180
C*************************************************************************MAIN5190
C-----CALCULATE STIFFNESS MATRIX DERIVATIVE                               MAIN5200
C*************************************************************************MAIN5210
      IF(NU.EQ.1) GO TO 501                                               MAIN5220
      FR=IFX *(FRC*ADLD(IDVAR))**(IFX -1  )                               MAIN5230
      DO 502 I=1,ND                                                       MAIN5240
      DO 502 J=1,ND                                                       MAIN5250
  502 S1(I,J)=S1(I,J)+S2(I,J)*FR                                          MAIN5260
  501 DO 300 I=1,ND                                                       MAIN5270
      DO 300 J=1,ND                                                       MAIN5280
  300 S1(I,J)=S1(I,J)*FRC                                                 MAIN5290
C*************************************************************************MAIN5300
C-----CALCULATE THE PRODUCT U(I) TRANSPOSE *STIFFNESS MATRIX DERIVATIVE   MAIN5310
C*************************************************************************MAIN5320
      DO 950 I=1,L1                                                       MAIN5330
      DO 950 J=1,ND                                                       MAIN5340
  950 C(I,J)=0.0                                                          MAIN5350
      DO 610 K=1,ND                                                       MAIN5360
      MM=LM(K)                                                            MAIN5370
      IF(MM.LE.0) GO TO 610                                               MAIN5380
      DO 600 I=1,L1                                                       MAIN5390
      DO 600 J=1,ND                                                       MAIN5400
  600 C(I,J)=C(I,J)+D(MM,I)*S1(K,J)                                       MAIN5410
  610 CONTINUE                                                            MAIN5420
      WRITE(I1) ND,IDVAR   ,((C(I,J),J=1,ND),I=1,L1),(LM(I),I=1,ND)       MAIN5430
  100 CONTINUE                                                            MAIN5440
      RETURN                                                              MAIN5450
      END                                                                 MAIN5460
```

```
      SUBROUTINE DUMAN(A,B,C,NEQB,MRAND,NBLOCK,LL,NDISP,I2,I10)          MAIN5470
C*************************************************************************MAIN5480
C-----PUT IN DUMMY LOADS FOR CALCULATION OF DISPLACEMENT DERIVATIVES     MAIN5490
      REAL*8 A(NEQB,MRAND),B(NEQB,LL),C(NEQB,NDISP)                      MAIN5510
      COMMON/JUNK/JUN(16),MLC(4),NEQ(4),DRAT(4),DCON(4) ,JUN1(268)       MAIN5520
      REWIND I2                                                          MAIN5530
      REWIND I10                                                         MAIN5540
      DO 10 L=1,NBLOCK                                                   MAIN5550
      READ(I10) A,B                                                      MAIN5560
      DO 20 I=1,NEQB                                                     MAIN5570
      DO 20 J=1,NDISP                                                    MAIN5580
   20 C(I,J)=0.0                                                         MAIN5590
      NT=(L-1)*NEQB                                                      MAIN5600
      NE=NT+NEQB                                                         MAIN5610
      DO 50 I=1,NDISP                                                    MAIN5620
      J=NEQ(I)                                                           MAIN5630
      IF(J.LE.NT) GO TO 50                                               MAIN5640
      IF(J.GT.NE) GO TO 50                                               MAIN5650
      C(J-NT,I)=1.                                                       MAIN5660
      IF(DRAT(I).LT.0) C(J-NT,I)=-1.0                                    MAIN5670
   50 CONTINUE                                                           MAIN5680
   10 WRITE(I2)A,C                                                       MAIN5690
      RETURN                                                             MAIN5700
      END                                                                MAIN5710


      SUBROUTINE DERV(QR1,D,B,NDISP,LB1,NUMDV,NEQ,NEQB,NBLOCK,NUMEL,I1,  MAIN5720
     1I3,I10,I11)                                                        MAIN5730
C*************************************************************************MAIN5740
C-----CALCULATE DISPLACEMENT DERIVATIVES                                 MAIN5750
C*************************************************************************MAIN5760
      DIMENSION QR1(NUMDV,LB1),D(NEQ,LB1)                                MAIN5770
      REAL*8 B(NEQB,NDISP)                                               MAIN5780
      COMMON/JUNK/JUN(32),ND,IDVAR,L1,C(4,24),LM(24) ,JUN1(145)          MAIN5790
      NT=(NDISP-1)/LB1+1                                                 MAIN5800
      LH=0                                                               MAIN5810
      REWIND I3                                                          MAIN5820
      DO 200 II=1,NT                                                     MAIN5830
C*************************************************************************MAIN5840
C-----MOVE DISPLACEMENTS INTO CORE FOR LB LOAD CONDITIONS.               MAIN5850
C*************************************************************************MAIN5860
      CALL MOVED(B,D,NEQB,NBLOCK,NEQ,NDISP,LB1,LH,LT,I10)                MAIN5870
      L1=LH-LT+1                                                         MAIN5880
      DO 50 I=1,NUMDV                                                    MAIN5890
      DO 50 J=1,L1                                                       MAIN5900
   50 QR1(I,J)=0.0                                                       MAIN5910
      DO 100 M=1,NUMEL                                                   MAIN5920
C*************************************************************************MAIN5930
C-----READ THE PRODUCT U(ACTUAL) TRANSPOSE* STIFFNESS MATR. DERIVATIVE   MAIN5940
C*************************************************************************MAIN5950
    4 READ(I1) ND,IDVAR  ,((C(I,J),J=1,ND),I=1,L1),(LM(I),I=1,ND)        MAIN5960
C*************************************************************************MAIN5970
C-----CALCULATE DERIVATIVES                                              MAIN5980
C*************************************************************************MAIN5990
      DO 100 I=1,ND                                                      MAIN6000
      MM=LM(I)                                                           MAIN6010
      IF(MM.LE.0) GO TO 100                                              MAIN6020
      DO 510 K=1,L1                                                      MAIN6030
```

```
  510 DR1(IDVAR,K)=DR1(IDVAR,K )-C(K,I)*D(MM,K)                          MAIN6040
  100 CONTINUE                                                          MAIN6050
C*******************************************************************MAIN6060
C-----WRITE DISPLACEMENT DERIVATIVES ON TAPE                            MAIN6070
C*******************************************************************MAIN6080
      DO 300 J=1,L1                                                     MAIN6090
  300 WRITE(13)(DR1(K,J),K=1,NUMDV)                                     MAIN6100
  200 CONTINUE                                                          MAIN6110
      RETURN                                                            MAIN6120
      END                                                               MAIN6130



      SUBROUTINE DISP(R,D,AMDA,NDISP,ICON)                              MAIN6140
C*******************************************************************MAIN6150
C-----FIND OUT ACTIVE LAMBDA'S(IF +VE DISP. CONSTRAINTS)                MAIN6160
C*******************************************************************MAIN6170
      DIMENSION R(4),D(4,4),AMDA(4)                                     MAIN6180
      ICON=NDISP                                                        MAIN6190
      IF(NDISP.GT.1) GO TO 900                                          MAIN6200
      AMDA(1)=R(1)/D(1,1)                                               MAIN6210
      IF(AMDA(1).GT.0.) RETURN                                          MAIN6220
      AMDA(1)=0.                                                        MAIN6230
      ICON=0                                                            MAIN6240
      RETURN                                                            MAIN6250
  900 IF(D(2,2).NE.0.) GO TO 10                                         MAIN6260
      IF(D(1,1).NE.0.) GO TO 11                                         MAIN6270
      AMDA(1)=0.                                                        MAIN6280
      AMDA(2)=0.                                                        MAIN6290
      ICON=0                                                            MAIN6300
      RETURN                                                            MAIN6310
   11 AMDA(1)=R(1)/D(1,1)                                               MAIN6320
      AMDA(2)=0.                                                        MAIN6330
      ICON=1                                                            MAIN6340
      IF(AMDA(1).GT.0.) RETURN                                          MAIN6350
      AMDA(1)=0.                                                        MAIN6360
      ICON=0                                                            MAIN6370
      RETURN                                                            MAIN6380
   10 IF(D(1,1).NE.0.) GO TO 20                                         MAIN6390
      AMDA(1)=0.                                                        MAIN6400
      AMDA(2)=R(2)/D(2,2)                                               MAIN6410
      ICON=1                                                            MAIN6420
      IF(AMDA(2).GT.0.) RETURN                                          MAIN6430
      AMDA(2)=0.                                                        MAIN6440
      ICON=0                                                            MAIN6450
      RETURN                                                            MAIN6460
   20 DEL=D(1,1)*D(2,2)-D(1,2)*D(1,2)                                   MAIN6470
      C1=D(1,1)*D(2,2)*1.0E-06                                          MAIN6480
      IF(ABS(DEL).GT.C1) GO TO 30                                       MAIN6490
      A1=R(1)/D(1,1)                                                    MAIN6500
      A2=R(2)/D(2,2)                                                    MAIN6510
      IF(A1.LE.0..AND.A2.LE.0.) GO TO 40                                MAIN6520
      IF(A2.GT.A1) GO TO 50                                             MAIN6530
      AMDA(1)=A1                                                        MAIN6540
      AMDA(2)=0.                                                        MAIN6550
      ICON=1                                                            MAIN6560
      RETURN                                                            MAIN6570
   50 AMDA(1)=0.                                                        MAIN6580
```

```
      AMDA(2)=A2                                                        MAIN6590
      ICON=1                                                            MAIN6600
      RETURN                                                            MAIN6610
   40 AMDA(1)=0.                                                        MAIN6620
      AMDA(2)=0.                                                        MAIN6630
      ICON=0                                                            MAIN6640
      RETURN                                                            MAIN6650
   30 AMDA(1)=(D(2,2)*R(1)-D(1,2)*R(2))/DEL                             MAIN6660
      AMDA(2)=(-D(2,1)*R(1)+D(1,1)*R(2))/DEL                            MAIN6670
      IF(AMDA(1).GT.0..AND.AMDA(2).GT.0.) RETURN                        MAIN6680
      IF(AMDA(1).GT.AMDA(2)) GO TO 60                                   MAIN6690
      AMDA(1)=0.                                                        MAIN6700
      AMDA(2)=R(2)/D(2,2)                                               MAIN6710
      ICON=1                                                            MAIN6720
      IF(AMDA(2).GT.0.) RETURN                                          MAIN6730
      AMDA(2)=0.                                                        MAIN6740
      ICON=0                                                            MAIN6750
      RETURN                                                            MAIN6760
   60 AMDA(1)=R(1)/D(1,1)                                               MAIN6770
      AMDA(2)=0.                                                        MAIN6780
      ICON=1                                                            MAIN6790
      IF(AMDA(1).GT.0.) RETURN                                          MAIN6800-
      AMDA(1)=0.                                                        MAIN6810
      ICON=0                                                            MAIN6820
      RETURN                                                            MAIN6830
      END                                                               MAIN6840
```

```
      SUBROUTINE DDESIN(ORI,ID1,ADLD,ASTR,ADIS,DWT,OPTIND,NUMDV,NDISP,  MAIN6850
     1 I1,I3,I8,IW)                                                     MAIN6860
C*********************************************************************MAIN6870
C-----CARRY OUT DISPLACEMENT REDESIGN OR SCALING                       MAIN6880
C*********************************************************************MAIN6890
      DIMENSION ID1(NUMDV),ADLD(NUMDV),ASTR(NUMDV),ADIS(NUMDV),         MAIN6900
     1ORI(NUMDV,NDISP),DWT(NUMDV) ,OPTIND(NUMDV)                        MAIN6910
      COMMON/CONTR/ ICYCL,MCYCL,ISCALE,NSCALE,KSCALE,KONVG,IDESN,IWTMIN,MAIN6920
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,KDISP,NMAXD,NDISS,LB1,ALPA,SF,IS,MAIN6930
     1 SMAX,DMAX,OMEGA                                                  MAIN6940
      COMMON/JUNK/JUN(16),ML(4),ME(4),DRAT(4),DCON(4),D(4,4),R(4),AMDA(4MAIN6950
     1),S(4)    ,JUN1(240)                                             MAIN6960
      DATA TAG1,TAG2/3HACT,4HPASS/                                      MAIN6970
      DEL5=5.0*(1.0-DELTA1)                                             MAIN6980
      DELT11=1.0-DEL5                                                   MAIN6990
      DELT22=1.0+DEL5                                                   MAIN7000
      BACKSPACE I8                                                      MAIN7010
      READ(I8) DWT                                                      MAIN7020
      REWIND I1                                                         MAIN7030
      READ (I1)ADLD                                                     MAIN7040
      REWIND I3                                                         MAIN7050
      DO 61 I=1,NDISP                                                   MAIN7060
   61 READ(I3)  (ORI(J,I),J=1,NUMDV)                                    MAIN7070
   60 IF(KONVG.EQ.1) GO TO 501                                          MAIN7080
C*********************************************************************MAIN7090
C-----DISPLACEMENT CONSTRAINT REDESIGN                                 MAIN7100
C*********************************************************************MAIN7110
      READ(I1) ASTR                                                     MAIN7120
      REWIND I1                                                         MAIN7130
      IF(IS.NE.1) GO TO 101                                             MAIN7140
C*********************************************************************MAIN7150
C-----CONVERT DISPLACEMENT RATIOS AND DERIVATIVES TO THE SCALED DESIGN  MAIN7160
C*********************************************************************MAIN7170
      DO 99 I=1,NUMDV                                                   MAIN7180
   99 ADLD(I)=ADLD(I)*SF                                                MAIN7190
      SFF=SF**KSCALE                                                    MAIN7200
      SFFF=SFF*SF                                                       MAIN7210
      DO 102 I=1,NDISP                                                  MAIN7220
      DRAT(I)=DRAT(I)/SFF                                               MAIN7230
      DO 102 J=1,NUMDV                                                  MAIN7240
  102 ORI(J,I)=ORI(J,I)/SFFF                                            MAIN7250
C*********************************************************************MAIN7260
C-----CLASSIFY DESIGN VARIABLES EITHER AS ACTIVE OR PASSIVE            MAIN7270
C-----DESIGN VARIABLES WITH THEIR DERIVATIVES FOR ALL POTENTIALLY      MAIN7280
C     ACTIVE DISPLACEMENT CONSTRAINTS AS POSITIVE ARE PASSIVE VARIABLES MAIN7290
C*********************************************************************MAIN7300
  101 DO 50 I=1,NUMDV                                                   MAIN7310
      DO 51 J=1,NDISP                                                   MAIN7320
      IF(ORI(I,J).LT.0.) GO TO 49                                       MAIN7330
   51 CONTINUE                                                          MAIN7340
      ID1(I)=0                                                          MAIN7350
      GO TO 50                                                          MAIN7360
   49 ID1(I)=1                                                          MAIN7370
   50 CONTINUE                                                          MAIN7380
C*********************************************************************MAIN7390
C-----ITERATION TO FIND OUT ACTIVE/PASSIVE CLASSIFICATION OF DESIGN    MAIN7400
C     VARIABLES                                                         MAIN7410
C*********************************************************************MAIN7420
  700 MAC=1                                                             MAIN7430
C*********************************************************************MAIN7440
```

```
C-----CHECK IF ALL DESIGN VARIABLES ARE PASSIVE                          MAIN7450
C*************************************************************************MAIN7460
      DO 52 I=1,NUMDV                                                   MAIN7470
      IF(ID1(I).EQ.1) GO TO 599                                         MAIN7480
   52 CONTINUE                                                          MAIN7490
C*************************************************************************MAIN7500
C-----ALL DESIGN VARIABLES ARE PASSIVE. TAKE STRESS DESIGN AND GO FOR    MAIN7510
C     NEXT DESIGN CYCLE                                                 MAIN7520
C*************************************************************************MAIN7530
      ICON=0                                                            MAIN7540
      GO TO 602                                                         MAIN7550
C*************************************************************************MAIN7560
C-----CALCULATE RIGHT HAND SIDES OF SIMULTANEOUS EQUATIONS FOR LAMBDAS   MAIN7570
C*************************************************************************MAIN7580
  599 DO 80 I=1,4                                                       MAIN7590
      R(I)=0.                                                           MAIN7600
      AMDA(I)=0.                                                        MAIN7610
      DO 80 J=1,4                                                       MAIN7620
   80 D(I,J)=0.                                                         MAIN7630
      DO 100 I=1,NDISP                                                  MAIN7640
      DP=0.0                                                            MAIN7650
      DA=0.0                                                            MAIN7660
      DO 110 J=1,NUMDV                                                  MAIN7670
      IF(ID1(J).EQ.1) GO TO 120                                         MAIN7680
      DP=DP+DR1(J,I)*(ASTR(J)-AOLD(J))                                  MAIN7690
      GO TO 110                                                         MAIN7700
  120 DA=DA+DR1(J,I)*AOLD(J)                                            MAIN7710
  110 CONTINUE                                                          MAIN7720
  100 R(I)=(1-ALPA)*DA+(1-ABS(DRAT(I)))*    DCON(I) -DP                 MAIN7730
C*************************************************************************MAIN7740
C-----DEVELOP COEFFICIENT MATRIX FOR LAMBDAS                            MAIN7750
C*************************************************************************MAIN7760
      DO 250 I=1,NDISP                                                  MAIN7770
      DO 250 J=I,NDISP                                                  MAIN7780
      D(I,J)=0.                                                         MAIN7790
      DO 260 K=1,NUMDV                                                  MAIN7800
      IF(ID1(K).EQ.1) D(I,J)=D(I,J)+DR1(K,I)*DR1(K,J)*AOLD(K)/UW1(K)    MAIN7810
  260 CONTINUE                                                          MAIN7820
      D(I,J)=-D(I,J)*(1.-ALPA)                                          MAIN7830
  250 D(J,I)=D(I,J)                                                     MAIN7840
C*************************************************************************MAIN7850
C-----ITERATION TO FIND ACTIVE DISPLACEMENT CONSTRAINTS(IF +VE LAMBDA'S)MAIN7860
C*************************************************************************MAIN7870
      CALL DISP(R,D,AMDA,NDISP,ICON)                                    MAIN7880
      IF(ICON.NE.0) GO TO 601                                           MAIN7890
  602 WRITE(IW,1006) ICON                                               MAIN7900
      WRITE(I1) ASTR                                                    MAIN7910
      GO TO 971                                                         MAIN7920
C*************************************************************************MAIN7930
C-----CALCULATE REDESIGN FROM DISPLACEMENT CONSTRAINTS                  MAIN7940
C*************************************************************************MAIN7950
  601 DO 500 I=1,NUMDV                                                  MAIN7960
      C=0.                                                              MAIN7970
      DO 510 J=1,NDISP                                                  MAIN7980
  510 C=C+AMDA(J)*DR1(I,J)                                              MAIN7990
      OPTIND(I)=C/UW1(I)                                                MAIN8000
      C=(ALPA-(1.-ALPA)*OPTIND(I))*AOLD(I)                              MAIN8010
      IF(C.GE.ASTR(I)) GO TO 520                                        MAIN8020
      IF(ID1(I).EQ.1) MAC=0                                             MAIN8030
      ID1(I)=0                                                          MAIN8040
```

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      ADJS(I)=ASTR(I)                                                   MAIN8050
      GO TO 500                                                         MAIN8060
  520 ADJS(I)=0                                                         MAIN8070
      IF(ID1(I).EQ.0) MAC=0                                             MAIN8080
      ID1(I)=1                                                          MAIN8090
  500 CONTINUE                                                          MAIN8100
C*********************************************************************MAIN8110
C-----CHECK FOR ANY CHANGE IN ACTIVE/PASSIVE CLASSIFICATION OF DESIGN   MAIN8120
C     VARIABLES                                                         MAIN8130
C*********************************************************************MAIN8140
      IF(MAC.EQ.0) GO TO 700                                            MAIN8150
C*********************************************************************MAIN8160
C-----PRINT OPTIMALITY INDEX                                            MAIN8170
C*********************************************************************MAIN8180
      WRITE(IW,2002)                                                    MAIN8190
      DO 750 I=1,NUMDV                                                  MAIN8200
      TAG=TAG1                                                          MAIN8210
      IF(ID1(I).EQ.0) TAG=TAG2                                          MAIN8220
  750 WRITE(IW,2003) I,TAG,OPTIND(I)                                    MAIN8230
      WRITE(IW,1006) ICON                                               MAIN8240
      IF(SF.GT.DELTA2.OR.SF.LT.DELTA1) GO TO 701                        MAIN8250
      IF(DMAX.GT.DELTA2.OR.DMAX.LT.DELTA1) GO TO 701                    MAIN8260
C*********************************************************************MAIN8270
C-----CHECK FOR DISPLACEMENT DESIGN CONVERGENCE.                        MAIN8280
C*********************************************************************MAIN8290
      DO 702 I=1,NUMDV                                                  MAIN8300
      IF(ID1(I).EQ.0) GO TO 702                                         MAIN8310
      C=-OPTIND(I)                                                      MAIN8320
      IF(C.GT.DELT22.OR.C.LT.DELT11) GO TO 701                          MAIN8330
  702 CONTINUE                                                          MAIN8340
      KONVG=4                                                           MAIN8350
      WRITE(IW,2001)                                                    MAIN8360
      RETURN                                                            MAIN8370
C*********************************************************************MAIN8380
C-----CALCULATE SCALE FACTOR FOR UNIFORM SCALING FROM DISPLACEMENT      MAIN8390
C     CONSTRAINTS                                                       MAIN8400
C*********************************************************************MAIN8410
  501 DO 503 J=1,NDISP                                                  MAIN8420
      S(J)=0                                                            MAIN8430
      DO 502 I=1,NUMDV                                                  MAIN8440
  502 S(J)=S(J)+DR1(I,J)*ADLD(I)                                        MAIN8450
  503 S(J)=DCON(J)*(1.0-ABS(DRAT(J)))/S(J)+1.                           MAIN8460
      DF=0.                                                             MAIN8470
      DO 504 I=1,NDISP                                                  MAIN8480
      IF(S(I).GT.DF)DF=S(I)                                             MAIN8490
  504 CONTINUE                                                          MAIN8500
      CALL MESG(SF,DF,DF,IW)                                            MAIN8510
      IF(DF.GT.SF)SF=DF                                                 MAIN8520
      DO 505 I=1,NUMDV                                                  MAIN8530
  505 ADJS(I)=ADLD(I)*SF                                                MAIN8540
      REWIND 11                                                         MAIN8550
  701 WRITE(11) ADJS                                                    MAIN8560
  971 RETURN                                                            MAIN8570
 1006 FORMAT(//1X,42HNO. OF ACTIVE DISPLACEMENT CONSTRAINTS ARE ,I5)    MAIN8580
 2001 FORMAT(43H DISPLACEMENT-CRITICAL DESIGN HAS CONVERGED //)         MAIN8590
 2002 FORMAT(//62H OPTIMALITY INDEX OF DESIGN VARIABLES FOR DISPT.  CONMAIN8600
     1STRAINTS  //5X,5HDV NO.,1X,7HACT/PAS,4X,5HINDEX  /)              MAIN8610
 2003 FORMAT(5X,I5,A10,E15.5)                                           MAIN8620
      END                                                               MAIN8630
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      SUBROUTINE TRUSS (A,MTOT)                                          TRUS0000
C*********************************************************************TRUS0010
C-----THREE DIMENSIONAL BAR ELEMENTS                                     TRUS0020
C*********************************************************************TRUS0030
      DIMENSION A(MTOT)                                                  TRUS0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTTT,NEQTRUS0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LR     ,NEQR,NBLOCK                      TRUS0060
      COMMON/JUNK/JUN(16),LT,LH,L,SIG(27),IDVAR,IEX,FRC,AREA,JUN1(250)   TRUS0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                   TRUS0080
      NUME=NPAR(2)                                                       TRUS0090
      KODE=NPAR(5)                                                       TRUS0100
      IF(NPAR(1).EQ.0)GO TO 500                                          TRUS0110
      GO TO (1,1,2),KODE                                                 TRUS0120
C*********************************************************************TRUS0130
C-----KODE =1  INERTIA IS PROPORTIONAL TO AREA FOR  LOCAL BUCKLING       TRUS0140
C          2 INERTIA IS PROPPORTIONAL TO AREA**2 FOR LOCAL BUCKLING      TRUS0150
C*********************************************************************TRUS0160
    1 NUMMAT=NPAR(3)                                                     TRUS0170
      NUMGEO=NPAR(4)                                                     TRUS0180
      NUMTC=NPAR(6)                                                      TRUS0190
      N6=N5+NUMNP                                                        TRUS0200
      N7=N6+NUMMAT                                                       TRUS0210
      N8=N7+NUMMAT                                                       TRUS0220
      N9=N8+NUMMAT*NUMTC*5                                               TRUS0230
      MM=N9+NUMGEO*2-MTOT                                                TRUS0240
      IF(MM.GT.0)CALL ERROR(MM)                                          TRUS0250
      CALL RUSS (A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),        TRUS0260
     1A(N8),A(N9),NUMDV,NUMNP,NUMMAT,NUMTC,NUMGEO,KODE,NUME)             TRUS0270
      RETURN                                                             TRUS0280
C*********************************************************************TRUS0290
C-----PROVISION FOR SPECIAL TRUSS ELEMENT                                TRUS0300
C*********************************************************************TRUS0310
    2 CALL NOELEM (NPAR(1),NPAR(5),IW)                                   TRUS0320
      RETURN                                                             TRUS0330
  500 WRITE (IW,2002)  KODE                                              TRUS0340
      DO 800 MM=1,NUME                                                   TRUS0350
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,IR,0)                 TRUS0360
      WRITE (IW,2005) MM,AREA                                            TRUS0370
      DO 800 L=LT,LH                                                     TRUS0380
      IF(L.GT.LT) WRITE(IW,2004)                                         TRUS0390
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,IR,1)                 TRUS0400
      WRITE(IW,2003)  L,SIG(1)                                           TRUS0410
      GO TO (3,3,4),KODE                                                 TRUS0420
C*********************************************************************TRUS0430
C-----DESIGN OF BAR ELEMENTS FOR STRESS AND LOCAL BUCKLING               TRUS0440
C*********************************************************************TRUS0450
    3 CALL DTRUSS (A(M1),A(M2),A(M3),NUMDV)                              TRUS0460
      GO TO 800                                                          TRUS0470
C*********************************************************************TRUS0480
C-----PROVISION FOR DESIGN OF SPECIAL TRUSS ELEMENT                      TRUS0490
C*********************************************************************TRUS0500
    4 CONTINUE                                                           TRUS0510
  800 CONTINUE                                                           TRUS0520
      RETURN                                                             TRUS0530
 2002 FORMAT(//42H ANALYSIS OF TRUSS ELEMENTS, CONSTRN CODE=,I2   //     TRUS0540
     1       47H ELEMENT  X-SECT AREA  LOAD COND   AXIAL FORCE  /)       TRUS0550
 2003 FORMAT(1H+,24X,I5,4X,E12.4)                                        TRUS0560
 2004 FORMAT(/)                                                          TRUS0570
 2005 FORMAT(I7,2X,E12.4)                                                TRUS0580
      END                                                                TRUS0590
```

```
      SUBROUTINE RUSS (IWT,ID,X,Y,Z,T,NTC,WT,PMAT,PGEO,NUMDV,NUMNP,      TRUS0600
     1 NUMMAT,NUMTC,NUMGEO,KODE,NUME)                                    TRUS0610
C*********************************************************************TRUS0620
C-----UNIFORM CROSS SECTION BAR ELEMENTS                                TRUS0630
C*********************************************************************TRUS0640
      IMPLICIT REAL*8 (A-H,O-Z)                                         TRUS0650
      REAL*4 X,Y,Z,T,WT,PMAT,PGEO,IWT,EPC,BUCKYY,BUCKZZ,EE3,EE4         TRUS0660
      DIMENSION ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),T(NUMNP),        TRUS0670
     1NTC(NUMMAT),WT(NUMMAT),PMAT(NUMTC,5,NUMMAT),PGEO(NUMGEO,2),       TRUS0680
     2 IWT(NUMDV)                                                       TRUS0690
      COMMON/EM/LM(6),S(6,6),P(6,4),ST(6),TT(4),XM(6),EM1(2454)         TRUS0700
      COMMON/JUNK/EMUL(4,4),EE(4),RHO,TEMP,XX(2),YY(2),ZZ(2),V(4),      TRUS0710
     1 JUN(236)                                                         TRUS0720
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                  TRUS0730
C*********************************************************************TRUS0740
C-----CONTROL INFORMATION                                               TRUS0750
C*********************************************************************TRUS0760
      MU=1                                                              TRUS0770
      MV=1                                                              TRUS0780
      MW=1                                                              TRUS0790
      MD=6                                                              TRUS0800
      MS=1                                                              TRUS0810
      MT=4                                                              TRUS0820
      IEX=KODE                                                          TRUS0830
      WRITE(IW,2000)NUME,KODE    ,NUMMAT,NUMTC,NUMGEO                   TRUS0840
C*********************************************************************TRUS0850
C-----MATERIAL PROPERTY CARDS                                           TRUS0860
C*********************************************************************TRUS0870
      WRITE(IW,2001)                                                    TRUS0880
      DO 10 I=1,NUMMAT                                                  TRUS0890
      READ (IR,1001)N,NTC(N),WT(N)                                      TRUS0900
      IF (NTC(N).EQ.0) NTC(N)=1                                         TRUS0910
      WRITE(IW,2002)N,NTC(N),WT(N)                                      TRUS0920
C*********************************************************************TRUS0930
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                         TRUS0940
C*********************************************************************TRUS0950
      NT=NTC(N)                                                         TRUS0960
      DO 10 J=1,NT                                                      TRUS0970
      READ (IR,2008) (PMAT(J,K,N),K=1,5)                                TRUS0980
      IF(PMAT(J,5,N).LE.0) PMAT(J,5,N)=PMAT(J,4,N)                      TRUS0990
      IF (J.NE.1) WRITE(IW,2009)                                        TRUS1000
   10 WRITE (IW,2010) (PMAT(J,K,N),K=1,5)                               TRUS1010
C*********************************************************************TRUS1020
C-----GEOMETRIC PROPERTY CARDS                                          TRUS1030
C*********************************************************************TRUS1040
      WRITE(IW,2006)                                                    TRUS1050
      DO 51 I=1,NUMGEO                                                  TRUS1060
      READ (IR,1006)N,AREA,(PGEO(N,J),J=1,2)                           TRUS1070
      IF(AREA.LE.0.0)AREA=1.0                                           TRUS1080
      DO 80 J=1,2                                                       TRUS1090
   80 IF (PGEO(N,J).LE.0.) PGEO(N,J)=1000000.                           TRUS1100
      WRITE(IW,2007)N,AREA,(PGEO(N,J),J=1,2)                            TRUS1110
      AA=AREA**IEX                                                      TRUS1120
      DO 51 J=1,2                                                       TRUS1130
   51 PGEO(N,J)=9.8696*PGEO(N,J)/AA                                     TRUS1140
C*********************************************************************TRUS1150
C-----ELEMENT LOAD MULTIPLIERS                                          TRUS1160
C*********************************************************************TRUS1170
      READ(IR,1003)EMUL                                                 TRUS1180
      WRITE(IW,2003)EMUL                                                TRUS1190
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C*****************************************************************************TRUS1200
C-----ELEMENT CARDS                                                             TRUS1210
C*****************************************************************************TRUS1220
      WRITE(IW,2005)                                                            TRUS1230
      N=1                                                                       TRUS1240
  100 READ(IR,1004) IEL,II,JJ,IMAT,IGEO,IDV  ,FRC,REFT,ELPYY,ELPZZ,INC         TRUS1250
      IF(IEL.LT.N) GO TO 700                                                    TRUS1260
      IF(FRC.LE.0.0) FRC=1.0                                                    TRUS1270
      IF(INC.EQ.0) INC=1                                                        TRUS1280
      IF(ELPYY.LE.0.0) ELPYY=1.0                                                TRUS1290
      IF(ELPZZ.LE.0.0) ELPZZ=1.0                                                TRUS1300
      KK=INC*(IEL-N)                                                            TRUS1310
      I=II-KK                                                                   TRUS1320
      J=JJ-KK                                                                   TRUS1330
      DO 500 NEL=N,IEL                                                          TRUS1340
      XX(1)=X(I)                                                                TRUS1350
      XX(2)=X(J)                                                                TRUS1360
      YY(1)=Y(I)                                                                TRUS1370
      YY(2)=Y(J)                                                                TRUS1380
      ZZ(1)=Z(I)                                                                TRUS1390
      ZZ(2)=Z(J)                                                                TRUS1400
C*****************************************************************************TRUS1410
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE            TRUS1420
C*****************************************************************************TRUS1430
      TEMP=0.5*(T(I)+T(J))                                                      TRUS1440
      CALL INTERP(PMAT,FF,NUMTC,NUMMAT,5,4,NTC(IMAT),IMAT,TEMP)                 TRUS1450
C*****************************************************************************TRUS1460
C-----FORM ELEMENT UNIT MATRICES AND LOAD VECTORS                               TRUS1470
C*****************************************************************************TRUS1480
      RHO=WT(IMAT)                                                              TRUS1490
      TEMP=TEMP-REFT                                                            TRUS1500
      CALL ETRUSS                                                               TRUS1510
      HH=FF(1)/(V(4)*V(4))                                                      TRUS1520
      BUCKYY=PGEO(IGEO,1)*HH*ELPYY                                              TRUS1530
      BUCKZZ=PGEO(IGEO,2)*HH*ELPZZ                                              TRUS1540
      FF3=FF(3)                                                                 TRUS1550
      FF4=FF(4)                                                                 TRUS1560
      UWT(IDV)=UWT(IDV)+RHO*V(4)*FRC                                            TRUS1570
C*****************************************************************************TRUS1580
C-----FORM LOCATION MATRIX AND COMPUTE BAND WIDTH                               TRUS1590
C*****************************************************************************TRUS1600
      DO 400 L=1,3                                                              TRUS1610
      LM(L)=ID(I,L)                                                             TRUS1620
  400 LM(L+3)=ID(J,L)                                                           TRUS1630
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IFX,FRC)                 TRUS1640
      WRITE (IR) NI,BUCKYY,BUCKZZ,FF3,FF4                                       TRUS1650
      WRITE(IW,2004) NEL,I,J,IMAT,IGEO,IDV,FRC,REFT,ELPYY,ELPZZ,NDIF            TRUS1660
C*****************************************************************************TRUS1670
C-----CHECK FOR MORE ELEMENTS                                                   TRUS1680
C*****************************************************************************TRUS1690
      I=I+INC                                                                   TRUS1700
      J=J+INC                                                                   TRUS1710
  500 CONTINUE                                                                  TRUS1720
      N=IEL+1                                                                   TRUS1730
      IF(N.LE.NUME) GO TO 100                                                   TRUS1740
      RETURN                                                                    TRUS1750
  700 WRITE(IW,2011)                                                            TRUS1760
      STOP                                                                      TRUS1770
 1001 FORMAT(2I5,F10.0)                                                         TRUS1780
 1003 FORMAT(4F10.0)                                                            TRUS1790
```

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 1004 FORMAT(6I5,4F10.0,I5)                                                    TRUS1800
 1006 FORMAT(I5,5X,3F10.0)                                                     TRUS1810
 2000 FORMAT(44H1NUMBER OF TRUSS ELEMENTS                    =,I5/            TRUS1820
     1        44H CONSTRUCTION CODE                          =,I5/            TRUS1830
     2        44H NUMBER OF MATERIALS                        =,I5/            TRUS1840
     3        44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5/             TRUS1850
     4        44H NUMBER OF DIFFERENT GEOMETRIES PROPS GIVEN=,I5)             TRUS1860
 2001 FORMAT(// 25H MATERIAL PROPERTY CARDS //                                 TRUS1870
     19IH MATERIAL   NUMBER    SPECIFIC                  YOUNGS    COEFFETRUS1880
     2 OF /--ALLOWABLE STRESSES--/ /                                           TRUS1890
     39IH  NUMBER   OF TEMPS    WEIGHT       TEMP       MODULUS   THERM ETRUS1900
     4XPAN   TENSION   COMPRESSION /)                                          TRUS1910
 2002 FORMAT(I6,5X,I5,F12.4)                                                   TRUS1920
 2003 FORMAT(// 25H ELEMENT LOAD MULTIPLIERS / 20X,1HA,14X,1HB,14X,1HC,       TRUS1930
     1 14X,1HD,/6H X-DIR,4F15.6/ 6H Y-DIR,4F15.6/ 6H Z-DIR,4F15.6/             TRUS1940
     2 6H  TEMP,4F15.6)                                                        TRUS1950
 2004 FORMAT(I7,1X,5I7,4F13.4,I7)                                              TRUS1960
 2005 FORMAT(// 23H PROCESSED ELEMENT DATA//                                   TRUS1970
     111H ELEMENT  /-NODE NOS-/  /--ELEMENT ID NOS-/   DESIGN VAR  REFETRUS1980
     2RENCE     END FIXITY COEFFICIENTS     BAND          /                   TRUS1990
     311H  NUMBER     I       J     MATL  GEOMY  D VAR     FRACTION      TTRUS2000
     4EMP          YY          ZZ        WIDTH          /)                   TRUS2010
 2006 FORMAT(// 25H GEOMETRIC PROPERTY CARDS//                                 TRUS2020
     14H GEOMETRY     X-SECT  /--MOMENTS OF INERTIA--/ /                       TRUS2030
     245H  NUMBER      AREA         YY          ZZ      /)                    TRUS2040
 2007 FORMAT(I6,2X,3F12.4)                                                     TRUS2050
 2008 FORMAT(5F10.0)                                                           TRUS2060
 2009 FORMAT(/)                                                                TRUS2070
 2010 FORMAT(1H+,30X,5F12.4)                                                   TRUS2080
 2011 FORMAT(28H TRUSS ELEMENT CARD IN ERROR )                                 TRUS2090
      END                                                                      TRUS2100
```

```
      SUBROUTINE ETRUSS                                                       TRUS2110
C*************************************************************************TRUS2120
C-----FORM TRUSS ELEMENT MATRICES                                             TRUS2130
C*************************************************************************TRUS2140
      IMPLICIT REAL*8 (A-H,O-Z)                                               TRUS2150
      COMMON/EM/LM(6),S(6,6),P(6,4),ST(6),TT(4),XM(6),EM1(2454)               TRUS2160
      COMMON/JUNK/EMUL(4,4),F(4),RHO,TEMP,X(2),Y(2),Z(2),V(4),JUN(236)        TRUS2170
      DIMENSION EMM(76)                                                       TRUS2180
      EQUIVALENCE (S,EMM)                                                     TRUS2190
      DO 5 I=1,76                                                             TRUS2200
    5 EMM(I)=0.                                                               TRUS2210
C*************************************************************************TRUS2220
C-----COMPUTE UNIT STIFFNESS AND LOAD MATRICES                                TRUS2230
C*************************************************************************TRUS2240
      CALL VECTOR (V,X(1),Y(1),Z(1),X(2),Y(2),Z(2))                           TRUS2250
      DO 10 I=1,3                                                             TRUS2260
      ST(I)=-V(I)/V(4)                                                        TRUS2270
   10 ST(I+3)=-ST(I)                                                          TRUS2280
      DO 300 L=1,6                                                            TRUS2290
      YY=ST(L)*F(1)*V(4)                                                      TRUS2300
      DO 250 K=L,6                                                            TRUS2310
      S(K,L)=ST(K)*YY                                                         TRUS2320
  250 S(L,K)=S(K,L)                                                           TRUS2330
  300 ST(L)=F(1)*ST(L)                                                        TRUS2340
```

```
C*************************************************************************TRUS2350
C-----GRAVITY AND THERMAL LOADS                                           TRUS2360
C*************************************************************************TRUS2370
      ET=-TEMP*E(1)*E(2)                                                  TRUS2380
      F=0.5*RHO*V(4)                                                      TRUS2390
      DO 350 L=1,4                                                        TRUS2400
      HH=EMUL(L,4)*ET                                                     TRUS2410
      TT(L)=HH                                                            TRUS2420
      DO 350 M=1,3                                                        TRUS2430
      P(M,L)=EMUL(L,M)*F+HH*V(M)                                          TRUS2440
  350 P(M+3,L)=EMUL(L,M)*F-HH*V(M)                                        TRUS2450
      RETURN                                                              TRUS2460
      END                                                                 TRUS2470
```

```
      SUBROUTINE DTRUSS(AOLD,ANEW,LOAD,NUMDV)                          TRUS2480
C*****************************************************************TRUS2490
C-----FULLY STRESSED DESIGN FOR TRUSS ELEMENTS                       TRUS2500
C*****************************************************************TRUS2510
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                    TRUS2520
      COMMON/JUNK/JUN(16),LT,LH,L,SG(27),IDVAR,IEX,ERC,AREA,XINERT,BYY, TRUS2530
     1 BZZ,TENS,COPI,JUN1(245)                                         TRUS2540
      P=SG(1)                                                          TRUS2550
      IF(P.GT.0.0)GO TO 100                                            TRUS2560
      P1=COPI*AREA                                                     TRUS2570
      P2=0.5*P1                                                        TRUS2580
      P=-P                                                             TRUS2590
      PEY=XINERT*BYY                                                   TRUS2600
      XLY=P/PEY                                                        TRUS2610
      RMAX=SQRT(XLY)                                                   TRUS2620
      CALL JOHNS (IEX,P,P1,P2,PEY,R)                                   TRUS2630
      IF (R.GT.RMAX) RMAX=R                                            TRUS2640
      PEZ=XINERT*BZZ                                                   TRUS2650
      XLZ=P/PEZ                                                        TRUS2660
      R=SQRT(XLZ)                                                      TRUS2670
      IF (R.GT.RMAX) RMAX=R                                            TRUS2680
      CALL JOHNS (IEX,P,P1,P2,PEZ,R)                                   TRUS2690
      IF (R.GT.RMAX) RMAX=R                                            TRUS2700
      GO TO 118                                                        TRUS2710
  100 P1=TENS*AREA                                                     TRUS2720
      RMAX=P/P1                                                        TRUS2730
  118 AA=RMAX*AOLD(IDVAR)                                              TRUS2740
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                   TRUS2750
      ANEW(IDVAR)=AA                                                   TRUS2760
      LOAD(IDVAR)=L                                                    TRUS2770
   60 CONTINUE                                                         TRUS2780
      RETURN                                                           TRUS2790
      END                                                              TRUS2800
```

```
      SUBROUTINE JOHNS (I,A,B,C,D,AA)                                  TRUS2810
C*****************************************************************TRUS2820
C-----JOHNSON'S PARABOLA USED FOR REDESIGN UNDER COMPRESSIVE FORCE    TRUS2830
C*****************************************************************TRUS2840
      GO TO (1,2,3),I                                                  TRUS2850
    1 AA=B-(B-C)*C/D                                                   TRUS2860
      IF (AA.LT.0.00001) GO TO 50                                      TRUS2870
      AA=A/AA                                                          TRUS2880
      RETURN                                                           TRUS2890
   50 AA=0.0                                                           TRUS2900
      RETURN                                                           TRUS2910
    2 AA=(A+((B-C)*C/D))/B                                             TRUS2920
      RETURN                                                           TRUS2930
    3 AA=SQRT(A**2+(4*B*C*(B-C)/D))                                    TRUS2940
      AA=(AA+A)/2/B                                                    TRUS2950
      RETURN                                                           TRUS2960
      END                                                              TRUS2970
```

```
      SUBROUTINE BEAM(A,MTOT)                                                BEAM0000
C*************************************************************************BEAM0010
C-----THREE DIMENSIONAL BEAM ELEMENTS                                        BEAM0020
C*************************************************************************BEAM0030
      DIMENSION A(MTOT)                                                      BEAM0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTTT,NEQBEAM0050
     1,NUMEL,NUMOV,M1,M2,M3,LL,LR,NEQR,NBLOCK                                BEAM0060
      COMMON/JUNK/JUNK(16),LT,LH,L,SIG(27),IDVAR,IEX,FRC,AREA,JUN1(250)      BEAM0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                       BEAM0080
      NUME=NPAR(2)                                                           BEAM0090
      KODE=NPAR(5)                                                           BEAM0100
      IF(NPAR(1).EQ.0) GO TO 500                                             BEAM0110
      GO TO (1,1,2),KODE                                                     BEAM0120
C*************************************************************************BEAM0130
C-----BEAM ELEMENTS WITH     INSTABILITY CONSTRAINTS                         BEAM0140
C-----KODE =1 INERTIAS AND MODULI ARE PROPORTIONAL TO AREA                   BEAM0150
C           2 INERTIAS AND MODULI ARE PROPORTIONAL TO AREA**2 AND            BEAM0160
C             AREA**1.5 RESPECTIVELY                                         BEAM0170
C*************************************************************************BEAM0180
    1 NUMMAT=NPAR(3)                                                         BEAM0190
      NUMGEO=NPAR(4)                                                         BEAM0200
      NUMFIX=NPAR(6)                                                         BEAM0210
      IF (NUMFIX.EQ.0) NUMFIX=1                                              BEAM0220
      N6=N5+NUMNP                                                            BEAM0230
      N7=N6+NUMGEO                                                           BEAM0240
      N8=N7+NUMGEO*9                                                         BEAM0250
      N9=N8+NUMMAT                                                           BEAM0260
      N10=N9+NUMMAT*5                                                        BEAM0270
      MM=N10+NUMFIX*12-MTOT                                                  BEAM0280
      IF(MM.GT.0)CALL ERROR(MM)                                              BEAM0290
      CALL BEAM (A(M1),A(N1),A(N2),A(N3),A(N4),A(N6),A(N7),A(N8),A(N9),      BEAM0300
     1A(N10),NUMOV,NUMNP,NUMGEO,NUMMAT,NUMFIX,KODE,NUME,NPAR(6))             BEAM0310
      RETURN                                                                 BEAM0320
C*************************************************************************BEAM0330
C-----PROVISION FOR SPECIAL BEAM ELEMENTS                                    BEAM0340
C*************************************************************************BEAM0350
    2 CALL NOELEM(NPAR(1),KODE,IW)                                           BEAM0360
      RETURN                                                                 BEAM0370
  500 WRITE (IW,2008) KODE                                                   BEAM0380
      DO 800 MM=1,NUME                                                       BEAM0390
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMOV,LL,LR,I8,0)                     BEAM0400
      WRITE (IW,2005) MM,AREA                                                BEAM0410
      DO 800 L=LT,LH                                                         BEAM0420
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMOV,LL,LR,I8,1)                     BEAM0430
      IF(L.GT.LT) WRITE(IW,2006)                                             BEAM0440
      WRITE(6,2007)    L,(SIG(I),I=1,12)                                     BEAM0450
      GO TO (3,3,4),KODE                                                     BEAM0460
C*************************************************************************BEAM0470
C-----DESIGN OF BEAM ELEMENTS FOR STRESS AND LOCAL BUCKLING CONSTRAINTS     BEAM0480
C*************************************************************************BEAM0490
    3 CALL DBEAM(A(M1),A(M2),A(M3),NUMOV)                                    BEAM0500
      GO TO 800                                                              BEAM0510
C*************************************************************************BEAM0520
C-----PROVISION FOR REDESIGN OF SPECIAL BEAM ELEMENTS                        BEAM0530
C*************************************************************************BEAM0540
    4 CONTINUE                                                               BEAM0550
  800 CONTINUE                                                               BEAM0560
      RETURN                                                                 BEAM0570
 2005 FORMAT(I7,F13.4)                                                       BEAM0580
 2006 FORMAT(/)                                                              BEAM0590
```

```
 2007 FORMAT(1H+,20X,I5,6X,6E12.4/32X,6E12.4)                                   BEAM0600
 2008 FORMAT(//41H ANALYSIS OF BEAM ELEMENTS, CONSTRN CODE= ,I2//               BEAM0610
     1104H ELEMENT X-SECT AREA  LOAD COND    AXIAL RX     SHEAR RY    SHEBEAM0620
     2AR RZ    TORQUE MX    MOMENT MY    MOMENT MZ /)                         BEAM0630
      END                                                                       BEAM0640


      SUBROUTINE BEAM(UWT,ID,X,Y,Z,KSEC,PGEO,WT,PMAT,SET,NUMDV,NUMNP,          BEAM0650
     1NUMGEO,NUMMAT,NUMEIX,KODE,NUME,NUMEX)                                    BEAM0660
C*************************************************************************BEAM0670
C-----UNIFORM CROSS-SECTION BEAM ELEMENTS                                       BEAM0680
C*************************************************************************BEAM0690
      IMPLICIT REAL*8 (A-H,O-Z)                                                 BEAM0700
      REAL*4 UWT,X,Y,Z, PGEO ,PMAT,SET,ERC                                      BEAM0710
      DIMENSION UWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),              BEAM0720
     1 KSEC(NUMGEO), PGEO (NUMGEO,9),PMAT(NUMMAT,6),SET(NUMEIX,12)              BEAM0730
     2 ,WT(NUMMAT)                                                              BEAM0740
      COMMON/EM/LM(24),S(24,24,2),P(24,4,2),ST(12,24,2),TT(12,4,2),             BEAM0750
     1 XM(24),EM1(481)                                                          BEAM0760
      COMMON/JUNK/EMUL(3,4),T(3,3),LC(4),JC(12),XX(3),YY(3),ZZ(3),IE(3),BEAM0770
     1 IX(3),IU(3),DL,JUN(210)                                                  BEAM0780
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                          BEAM0790
C*************************************************************************BEAM0800
C-----CONTROL INFORMATION                                                       BEAM0810
C*************************************************************************BEAM0820
      NU=2                                                                      BEAM0830
      NV=2                                                                      BEAM0840
      NS=12                                                                     BEAM0850
      NW=2                                                                      BEAM0860
      IEX=KODE                                                                  BEAM0870
      NI=10                                                                     BEAM0880
      WRITE(IW,2005) NUME,KODE,NUMMAT,NUMGEO,NUMEX                              BEAM0890
C*************************************************************************BEAM0900
C-----MATERIAL PROPERTY CARDS                                                   BEAM0910
C*************************************************************************BEAM0920
      WRITE (IW,2001)                                                           BEAM0930
      DO 10 I=1,NUMMAT                                                          BEAM0940
      READ(IR,1001) N,WT(N),(PMAT(N,J),J=1,5)                                   BEAM0950
      IF(PMAT(N,4).LE.0.) PMAT(N,4)=PMAT(N,3)                                   BEAM0960
      IF(PMAT(N,5).LE.0.) PMAT(N,5)=0.577*PMAT(N,3)                             BEAM0970
      WRITE(IW,2002) N,WT(N),(PMAT(N,J),J=1,5)                                  BEAM0980
   10 PMAT(N,2)=0.5*PMAT(N,1)/(1.0+PMAT(N,2))                                   BEAM0990
C*************************************************************************BEAM1000
C-----GEOMETRIC PROPERTY CARDS                                                  BEAM1010
C*************************************************************************BEAM1020
      WRITE (IW,2003)                                                           BEAM1030
      DO 30 I=1,NUMGEO                                                          BEAM1040
      READ (IR,1002) N,KSEC(N),AREA,( PGEO (N,J),J=1,9)                         BEAM1050
      IF(AREA.LE.0.) AREA=1.0                                                   BEAM1060
      IF (KSEC(N).EQ.0) KSEC(N)=1                                               BEAM1070
      IF(KSEC(N).NE.3) GO TO 15                                                 BEAM1080
      PGEO(N,3)=PGEO(N,2)                                                       BEAM1090
      PGEO(N,6)=0.                                                              BEAM1100
      PGEO(N,7)=0.                                                              BEAM1110
      PGEO(N,8)=0.                                                              BEAM1120
      PGEO(N,9)=0.                                                              BEAM1130
   15 WRITE(IW,2004) N,KSEC(N),AREA,( PGEO (N,J),J=1,9)                         BEAM1140
      AA=AREA**IEX                                                              BEAM1150
      AAA=DSQRT(AREA*AA)                                                        BEAM1160
      DO 11 J=1,3                                                               BEAM1170
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   11 PGEO(N,J)=PGEO(N,J)/AA                                                    BEAM1180
      DO 12 J=4,9                                                               BEAM1190
   12 PGEO(N,J)=PGEO(N,J)/AAA                                                   BEAM1200
   30 CONTINUE                                                                  BEAM1210
C*****************************************************************************BEAM1220
C-----ELEMENT LOAD MULTIPLIERS                                                  BEAM1230
C*****************************************************************************BEAM1240
      READ (IR,1006) ((EMUL(I,J),J=1,4),I=1,3)                                  BEAM1250
      WRITE(IW,2006) ((EMUL(I,J),J=1,4),I=1,3)                                  BEAM1260
C*****************************************************************************BEAM1270
C-----FIXED-END FORCES                                                          BEAM1280
C*****************************************************************************BEAM1290
      IF(NUMFX .EQ.0) GO TO 56                                                  BEAM1300
      WRITE (IW,2010)                                                           BEAM1310
      DO 55 I=1,NUMFX                                                           BEAM1320
      READ (IR,1005) N,(SET(N,J),J=1,12)                                        BEAM1330
   55 WRITE(IW,2011) N,(SET(N,J),J=1,12)                                        BEAM1340
C*****************************************************************************BEAM1350
C-----ELEMENT CARDS                                                             BEAM1360
C*****************************************************************************BEAM1370
   56 WRITE (IW,4000)                                                           BEAM1380
      N=1                                                                       BEAM1390
  100 READ(IR,3000) IEL,IE,IMAT,IGEO,IDV   ,ERC,LC,JC,INC                      BEAM1400
      IF(ERC.LE.0.) ERC=1.                                                      BEAM1410
      IF (INC.EQ.0) INC=1                                                       BEAM1420
      KK=INC*(IEL-N)                                                            BEAM1430
      IX(1)=IE(1)-KK                                                            BEAM1440
      IX(2)=IE(2)-KK                                                            BEAM1450
      IX(3)=IE(3)                                                               BEAM1460
      DO 500 NEL=N,IEL                                                          BEAM1470
      DO 120 I=1,3                                                              BEAM1480
      II=IX(I)                                                                  BEAM1490
      XX(I)=X(II)                                                               BEAM1500
      YY(I)=Y(II)                                                               BEAM1510
  120 ZZ(I)=Z(II)                                                               BEAM1520
C*****************************************************************************BEAM1530
C-----COMPUTE ELEMENT MATRICES                                                  BEAM1540
C*****************************************************************************BEAM1550
      RHO=WT(IMAT)                                                              BEAM1560
      E  =PMAT(IMAT,1)                                                          BEAM1570
      G  =PMAT(IMAT,2)                                                          BEAM1580
      AAX=PGEO(IGEO,1)                                                          BEAM1590
      AAY=PGEO(IGEO,2)                                                          BEAM1600
      AAZ=PGEO(IGEO,3)                                                          BEAM1610
      CALL NEWBM(E,G,RHO,AAX,AAY,AAZ,SET,NUMFIX,NEL,IW)                         BEAM1620
      TWT(IDV)=TWT(IDV)+DL*RHO*ERC                                              BEAM1630
C*****************************************************************************BEAM1640
C-----FORM ELEMENT LOCATION MATRIX                                              BEAM1650
C*****************************************************************************BEAM1660
      I=IX(1)                                                                   BEAM1670
      J=IX(2)                                                                   BEAM1680
      DO 170 M=1,6                                                              BEAM1690
      LM(M)=ID(I,M)                                                             BEAM1700
      LM(M+12)=0                                                                BEAM1710
      LM(M+18)=0                                                                BEAM1720
  170 LM(M+6)=ID(J,M)                                                           BEAM1730
C*****************************************************************************BEAM1740
C-----TRANSFORM TO MASTER DEGREES OF FREEDOM  AND REARRANGE MATRICES           BEAM1750
C*****************************************************************************BEAM1760
      MD=12                                                                     BEAM1770
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      CALL SLAVE (X,Y,Z,ID,NUMNP,IX(1),IX(2),ND,NS)                    BEAM1780
      NN=NU*ND*NU                                                      BEAM1790
      CALL REARAN( S, S,24,24,2,ND,ND,NU,NN)                           BEAM1800
      NN=NS*ND*NU                                                      BEAM1810
      CALL REARAN(ST,ST,12,24,2,NS,ND,NU,NN)                           BEAM1820
      NN=ND*4*NV                                                       BEAM1830
      CALL REARAN( P, P,24, 4,2,ND, 4,NV,NN)                           BEAM1840
C*******************************************************************BEAM1850
C-----PLACE ELEMENT INFORMATION ON TAPES                               BEAM1860
C*******************************************************************BEAM1870
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,ERC)        BEAM1880
      WRITE(18) NI,(PGEO(IGEO,I),I=4,9),(PMAT(IMAT,I),I=3,5),KSEC(IGEO) BEAM1890
      WRITE (IW,4001) NEL,IX,IMAT,IGEO,IDV  ,ERC,LC,JC,NDIF           BEAM1900
C*******************************************************************BEAM1910
C-----CHECK FOR LAST ELEMENT                                           BEAM1920
C*******************************************************************BEAM1930
      IX(1)=IX(1)+INC                                                  BEAM1940
      IX(2)=IX(2)+INC                                                  BEAM1950
  500 CONTINUE                                                         BEAM1960
      N=IEL+1                                                          BEAM1970
      IF(N.LE.NUME ) GO TO 100                                         BEAM1980
      RETURN                                                           BEAM1990
 1001 FORMAT(I5,5X,6E10.0)                                             BEAM2000
 1002 FORMAT(2I5,4E10.0/6E10.0)                                        BEAM2010
 1005 FORMAT(I5,6E10.0/E15.0,5E10.0)                                   BEAM2020
 1006 FORMAT (4E10.0)                                                  BEAM2030
 2001 FORMAT(// 25H MATERIAL PROPERTY CARDS //                         BEAM2040
     183H MATERIAL      SPECIFIC      YOUNGS     POISSONS  /--------ALLOWABBEAM2050
     2LE STRESSES--------/ /                                           BEAM2060
     383H  NUMBER         WEIGHT      MODULUS      RATIO        TENSION   COMBEAM2070
     4PRESSION     SHEAR     /)                                        BEAM2080
 2002 FORMAT(I6,4X,6E12.4)                                             BEAM2090
 2003 FORMAT(// 25H GEOMETRIC PROPERTY CARDS//                         BEAM2100
     166H PROPERTY  X-SECT     X-SECT  /------PROPERTIES OF X-SECTION----BEAM2110
     2-/ /                                                             BEAM2120
     366H  NUMBER     CODE       AREA        X-AXIS       Y-AXIS       Z-AXISBEAM2130
     4   /)                                                            BEAM2140
 2004 FORMAT(I6,4X,I5,4E12.4,22H MOMENTS OF INERTIA     /              BEAM2150
     1             27X,3E12.4,24H SECT MODULI FOR POINT A/             BEAM2160
     2             27X,3E12.4,24H SECT MODULI FOR POINT B)             BEAM2170
 2005 FORMAT(32H1THREE DIMENSIONAL BEAM ELEMENTS//                     BEAM2180
     1         32H NUMBER OF BEAM ELEMENTS          =,I5/              BEAM2190
     2         32H CONSTRUCTION CODE                =,I5/              BEAM2200
     3         32H NUMBER OF MATERIALS              =,I5/              BEAM2210
     4         32H NUMBER OF GEOMETRIC PROPERTIES=,I5/                 BEAM2220
     5         32H NUMBER OF FIXED-END FORCE SETS=,I5)                 BEAM2230
 2006 FORMAT(// 25H ELEMENT LOAD MULTIPLIERS / 20X,1HA,14X,1HB,14X,1HC, BEAM2240
     1 14X,1HD,/6H X-DIR,4E15.6/ 6H Y-DIR,4E15.6/ 6H Z-DIR,4E15.6/ )   BEAM2250
 2010 FORMAT(1H1,40H FIXED END FORCES IN LOCAL COORDINATES              BEAM2260
     1//50H TYPE    NODE        FORCE X      FORCE Y      FORCE Z    ,  BEAM2270
     2                  35H MOMENT X     MOMENT Y     MOMENT Z         )BEAM2280
 2011 FORMAT(1H ,I3,6X,1HI,3X,6E12.3/1H ,9X,1HJ,3X,6E12.3/)            BEAM2290
 3000 FORMAT (7I5,E10.0,4I5,12I1,I3)                                   BEAM2300
 4000 FORMAT(// 23H PROCESSED ELEMENT DATA//                           BEAM2310
     1 106H ELEMENT  /---NODE NOS--/  /--ELEMENT ID NOS-/  DESIGN VAR  BEAM2320
     2 FIXED END-FORCE ID   END RELEASE CODES    BAND       /          BEAM2330
     3 107H  NUMBER       I     J     K    MATL  GEOMY  D VAR    FRACTION   BEAM2340
     4   A     B     C     D      I           J    WIDTH          /)  BEAM2350
 4001 FORMAT(17,2X,3I5,3I7,E12.4,2X,4I5,5X,6I1,5X,6I1,I6)              BEAM2360
      END                                                              BEAM2370
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      SUBROUTINE NEWRM (E,G,WJ,AAX,AAY,AAZ,SET,NUMFIX, NEL,IW)          BEAM2380
C*************************************************************************BEAM2390
C-----CALCULATE ELEMENT MATRICES                                         BEAM2400
C*************************************************************************BEAM2410
      IMPLICIT REAL*8 (A-H,O-Z)                                          BEAM2420
      REAL*4 SET                                                         BEAM2430
      COMMON/EM/LM(24),S1(24,24),S2(24,24),P1(24,4),P2(24,4),ST1(12,24),BEAM2440
     1 ST2(12,24),TT1(12,4),TT2(12,4),XM(24),S(12,12),FM1(337)          BEAM2450
      COMMON/JUNK/EMUL(3,4),I(3,3),LC(4),JC(12),XX(3),YY(3),ZZ(3),IE(3),BEAM2460
     1 IX(3),U(4),V(4),W(4),R(12),JUM(170)                              BEAM2470
      DIMENSION SET(NUMFIX,12),EMM(2184)                                 BEAM2480
      EQUIVALENCE (S),EMM)                                               BEAM2490
      DO 5 I=1,2184                                                      BEAM2500
    5 EMM(I)=0.                                                          BEAM2510
C*************************************************************************BEAM2520
C-----FORM GLOBAL TO LOCAL COORDINATE TRANSFORMATION.                    BEAM2530
C*************************************************************************BEAM2540
      CALL VECTOR(U,XX(1),YY(1),ZZ(1),XX(2),YY(2),ZZ(2))                 BEAM2550
      CALL VECTOR(V,XX(1),YY(1),ZZ(1),XX(3),YY(3),ZZ(3))                 BEAM2560
      HH=DOT(U,V)                                                        BEAM2570
      IF(DABS(HH*HH-1.0).LT.0.01 ) GO TO 40                              BEAM2580
      CALL CROSS(U,V,W)                                                  BEAM2590
      CALL CROSS(W,U,V)                                                  BEAM2600
      DO 30 I=1,3                                                        BEAM2610
      T(1,I)=U(I)                                                        BEAM2620
      T(2,I)=V(I)                                                        BEAM2630
   30 T(3,I)=W(I)                                                        BEAM2640
C*************************************************************************BEAM2650
C-----FIXED END FORCES IN LOCAL COORDINATES                              BEAM2660
C*************************************************************************BEAM2670
      DO 73 N=1,4                                                        BEAM2680
      M=LC(N)                                                            BEAM2690
      IF(M.LE.0) GO TO 73                                                BEAM2700
      DO 72 I=1,12                                                       BEAM2710
   72 TT2(I,N)=SET(M,I)                                                  BEAM2720
   73 CONTINUE                                                           BEAM2730
C*************************************************************************BEAM2740
C-----ELEMENT UNIT STIFFNESS MATRIX IN LOCAL COORDINATES S(I,J)          BEAM2750
C*************************************************************************BEAM2760
      DL=U(4)                                                            BEAM2770
      ZY=E/(DL*DL)                                                       BEAM2780
      COMMY=ZY*AAY                                                       BEAM2790
      COMMZ=ZY*AAZ                                                       BEAM2800
      S(1,1)=E/DL                                                        BEAM2810
      S(2,2)= COMMZ*12./DL                                               BEAM2820
      S(3,3)= COMMY*12./DL                                               BEAM2830
      S(4,4)=G*AAX/DL                                                    BEAM2840
      S(5,5)= COMMY* 4.*DL                                               BEAM2850
      S(6,6)= COMMZ* 4.*DL                                               BEAM2860
      S(2,6)= COMMZ* 6.                                                  BEAM2870
      S(3,5)=-COMMY* 6.                                                  BEAM2880
      DO 102 I=1,6                                                       BEAM2890
      J=I+6                                                              BEAM2900
  102 S(J,J)=S(I,I)                                                      BEAM2910
      DO 104 I=1,4                                                       BEAM2920
      J=I+6                                                              BEAM2930
  104 S(I,J)=-S(I,I)                                                     BEAM2940
      S(5,11)= S(5,5)*0.5                                                BEAM2950
      S(6,12)= S(6,6)*0.5                                                BEAM2960
      S(2,12)= S(2,6)                                                    BEAM2970
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      S(6, 8)=-S(2,6)                                                   BEAM2980
      S(8,12)=-S(2,6)                                                   BEAM2990
      S(3,11)= S(3,5)                                                   BEAM3000
      S(5, 9)=-S(3,5)                                                   BEAM3010
      S(9,11)=-S(3,5)                                                   BEAM3020
      DO 106 I=2,12                                                     BEAM3030
      K=I-1                                                             BEAM3040
      DO 106 J=1,K                                                      BEAM3050
  106 S(I,J)=S(J,I)                                                     BEAM3060
C***********************************************************************BEAM3070
C-----MODIFY S AND TT2 FOR ZERO END-FORCES                              BEAM3080
C***********************************************************************BEAM3090
      DO 140 I=1,12                                                     BEAM3100
      SI=S(I,I)                                                         BEAM3110
      IF(JC(I).LE.0.OR.SI.EQ.0.) GO TO 140                              BEAM3120
      DO 125 N=1,12                                                     BEAM3130
  125 R(N)=S(I,N)                                                       BEAM3140
      DO 126 N=1,4                                                      BEAM3150
  126 W(N)=TT2(I,N)                                                     BEAM3160
      DO 135 M=1,12                                                     BEAM3170
      CM=S(M,I)/SI                                                      BEAM3180
      DO 130 N=1,12                                                     BEAM3190
  130 S(M,N)=S(M,N)-CM*R(N)                                             BEAM3200
      DO 135 N=1,4                                                      BEAM3210
  135 TT2(M,N)=TT2(M,N)-CM*W(N)                                         BEAM3220
  140 CONTINUE                                                          BEAM3230
C***********************************************************************BEAM3240
C-----UNIT STIFFNESS AND FORCE RECOVERY MATRICES DUE TO STRETCHING       BEAM3250
C***********************************************************************BEAM3260
      DO 200 I=1,3                                                      BEAM3270
      DO 201 J=1,3                                                      BEAM3280
      X=T(1,I)*T(1,J)                                                   BEAM3290
      ST(I  ,J  )=X*S(1,1)                                              BEAM3300
      ST(I  ,J+6)=X*S(1,7)                                              BEAM3310
      ST(I+6,J  )=X*S(7,1)                                              BEAM3320
  201 ST(I+6,J+6)=X*S(7,7)                                              BEAM3330
      ST1(I  ,I  )=T(1,I)*S(1,1)                                        BEAM3340
      X=T(1,I)*S(1,7)                                                   BEAM3350
      ST1(I  ,I+6)=X                                                    BEAM3360
      ST1(7  ,I  )=X                                                    BEAM3370
  200 ST1(7  ,I+6)=T(1,I)*S(7,7)                                        BEAM3380
      DO 202 I=1,7,6                                                    BEAM3390
      DO 202 J=1,7,6                                                    BEAM3400
  202 S(I,J)=0.                                                         BEAM3410
C***********************************************************************BEAM3420
C-----UNIT FORCE RECOVERY MATRIX DUE TO BENDING AND TWISTING            BEAM3430
C***********************************************************************BEAM3440
      DO 150 LA=1,10,3                                                  BEAM3450
      LB=LA+2                                                           BEAM3460
      DO 150 MA=1,10,3                                                  BEAM3470
      MB=MA-1                                                           BEAM3480
      DO 150 I=LA,LB                                                    BEAM3490
      DO 150 JM=1,3                                                     BEAM3500
      J=JM+MB                                                           BEAM3510
      X=0.                                                              BEAM3520
      DO 151 K=1,3                                                      BEAM3530
  151 X =X +S(I,K+MB)*T(K,JM)                                           BEAM3540
  150 ST2(I,J)=X                                                        BEAM3550
C***********************************************************************BEAM3560
C-----COORDINATE TRANSFORMATION OF UNIT BENDING AND TWISTING STIFFNESS  BEAM3570
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C*************************************************************************BEAM3580
      DO 160 LA=1,10,3                                                   BEAM3590
      LB=LA-1                                                            BEAM3600
      DO 160 MA=1,10,3                                                   BEAM3610
      MB=MA+2                                                            BEAM3620
      DO 160 IL=1,3                                                      BEAM3630
      I=IL+LB                                                            BEAM3640
      DO 160 J=MA,MB                                                     BEAM3650
      X=0.                                                               BEAM3660
      DO 161 K=1,3                                                       BEAM3670
  161 X=X+T(K,IL)*ST2(K+LB,J)                                            BEAM3680
  160 S2(I,J)=X                                                          BEAM3690
C*************************************************************************BEAM3700
C-----TRANSFORMATION OF ELEMENT LOAD VECTOR DUE TO FIXED END FORCES     BEAM3710
C     TO GLOBAL COORDINATES                                              BEAM3720
C*************************************************************************BEAM3730
      DO 165 LA=1,10,3                                                   BEAM3740
      LB=LA-1                                                            BEAM3750
      DO 165 IL=1,3                                                      BEAM3760
      I=IL+LB                                                            BEAM3770
      DO 165 N=1,4                                                       BEAM3780
      X=0.                                                               BEAM3790
      DO 162 K=1,3                                                       BEAM3800
  162 X=X-T(K,IL)*TT2(K+LB,N)                                            BEAM3810
  165 P2(I,N)=X                                                          BEAM3820
C*************************************************************************BEAM3830
C-----ELEMENT MASS MATRIX                                                BEAM3840
C*************************************************************************BEAM3850
      X  =WT*DL/2.                                                       BEAM3860
      DO 180 M=1,3                                                       BEAM3870
      XM(M)=X                                                            BEAM3880
      XM(M+3)=0.                                                         BEAM3890
      XM(M+9)=0.                                                         BEAM3900
  180 XM(M+6)=X                                                          BEAM3910
C*************************************************************************BEAM3920
C-----COMPUTE GRAVITY LOADING ( POINT LOADS ONLY )                       BEAM3930
C*************************************************************************BEAM3940
      DO 190 I=1,3                                                       BEAM3950
      DO 190 J=1,4                                                       BEAM3960
      P1(I  ,J)=P1(I  ,J)+EMUL(I,J)*XM(I  )                              BEAM3970
  190 P1(I+6,J)=P1(I+6,J)+EMUL(I,J)*XM(I+6)                              BEAM3980
      RETURN                                                             BEAM3990
   40 WRITE(IW,4002) NEL                                                 BEAM4000
      STOP                                                               BEAM4010
 4002 FORMAT (9H0BEAM NO ,I5, 26H     K NODE ON BEAM X-AXIS              BEAM4020
     .  26H......EXECUTION TERMINATED )                                  BEAM4030
      END                                                                BEAM4040
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      SUBROUTINE SLAVE (X,Y,Z,ID,NUMNP,NI,NJ,ND,NS)                     BEAM4050
C*************************************************************************BEAM4060
C-----PERFORMS SLAVE ...MASTER DISPLACEMENT TRANSFORMATION               BEAM4070
C        ( FOR NODES CONNECTED TO BEAM ELEMENTS ONLY)                    BEAM4080
C*************************************************************************BEAM4090
      IMPLICIT REAL*8 (A-H,O-Z)                                          BEAM4100
      REAL*4 X,Y,Z                                                      BEAM4110
      COMMON/BM/LM(24),S(24,24,2),P(192),ST(12,24,2),TT(96),XM(24),      BEAM4120
     1 BM1(48)                                                          BEAM4130
      DIMENSION X(NUMNP),Y(NUMNP),Z(NUMNP),ID(NUMNP,6)                  BEAM4140
C*************************************************************************BEAM4150
C-----DETERMINE REQUIRED TRANSLATION DEGREES OF FREEDOM                  BEAM4160
C*************************************************************************BEAM4170
      DO 54 NF=1,12,6                                                   BEAM4180
      NOD=NI                                                            BEAM4190
      IF (NF.EQ.7) NOD=NJ                                               BEAM4200
      DO 30 K=1,3                                                       BEAM4210
      I=K+NF-1                                                          BEAM4220
      IF (LM(I).GE.0) GO TO 30                                          BEAM4230
      M=-LM(I)                                                          BEAM4240
      LM(I)=ID(M,K)                                                     BEAM4250
      N1=ND+1                                                           BEAM4260
      N2=ND+2                                                           BEAM4270
      IF(K-2) 35,45,55                                                  BEAM4280
   35 D1=-(Y(NOD)-Y(M))                                                 BEAM4290
      D2=   Z(NOD)-Z(M)                                                 BEAM4300
      LM(N1)=ID(M,6)                                                    BEAM4310
      LM(N2)=ID(M,5)                                                    BEAM4320
      GO TO 50                                                          BEAM4330
   45 D1=-(Z(NOD)-Z(M))                                                 BEAM4340
      D2=   X(NOD)-X(M)                                                 BEAM4350
      LM(N1)=ID(M,4)                                                    BEAM4360
      LM(N2)=ID(M,6)                                                    BEAM4370
      GO TO 50                                                          BEAM4380
   55 D1=-(X(NOD)-X(M))                                                 BEAM4390
      D2=   Y(NOD)-Y(M)                                                 BEAM4400
      LM(N1)=ID(M,5)                                                    BEAM4410
      LM(N2)=ID(M,4)                                                    BEAM4420
   50 CONTINUE                                                          BEAM4430
C*************************************************************************BEAM4440
C-----TRANSFORMATION...ARRAYS INCREASE IN SIZE                           BEAM4450
C*************************************************************************BEAM4460
      DO 80 JJ=1,2                                                      BEAM4470
      DO 60 II=1,ND                                                     BEAM4480
      S(N1,II,JJ)=S(I,II,JJ)*D1                                         BEAM4490
      S(N2,I,JJ)=S(I,II,JJ)*D2                                          BEAM4500
      S(II,N1,JJ)=S(N1,II,JJ)                                           BEAM4510
   60 S(II,N2,JJ)=S(N2,II,JJ)                                           BEAM4520
      S(N1,N1,JJ)=S(I,I,JJ)*D1*D1                                       BEAM4530
      S(N1,N2,JJ)=S(I,I,JJ)*D1*D2                                       BEAM4540
      S(N2,N1,JJ)=S(N1,N2,JJ)                                           BEAM4550
      S(N2,N2,JJ)=S(I,I,JJ)*D2*D2                                       BEAM4560
      DO 70 II=1,NS                                                     BEAM4570
      ST(II,N1,JJ)=ST(II,I,JJ)*D1                                       BEAM4580
   70 ST(II,N2,JJ)=ST(II,I,JJ)*D2                                       BEAM4590
   80 CONTINUE                                                          BEAM4600
      XM(N1)=XM(I)*D1*D1                                                BEAM4610
      XM(N2)=XM(I)*D2*D2                                                BEAM4620
      ND=ND+2                                                           BEAM4630
   30 CONTINUE                                                          BEAM4640
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C*******************************************************************************BEAM4650
C-----SET ROTATIONS                                                              BEAM4660
C*******************************************************************************BEAM4670
      DO 54 J=1,3                                                                BEAM4680
      K=NF+J+2                                                                   BEAM4690
      IF(LM(K).GE.0)  GO TO 54                                                   BEAM4700
      M=-LM(K)                                                                   BEAM4710
      LM(K)=ID(M,J+3)                                                            BEAM4720
   54 CONTINUE                                                                   BEAM4730
      RETURN                                                                     BEAM4740
      END                                                                        BEAM4750



      SUBROUTINE CBRT (A0,A1,A2,A3,Z)                                            BEAM4760
C*******************************************************************************BEAM4770
C-----COMPUTES THE LARGEST REAL ROOT Z OF                                        BEAM4780
C     A0+A1*Z+A2*Z**2+A3*Z**3=0                                                  BEAM4790
C*******************************************************************************BEAM4800
      A0=A0/A3                                                                   BEAM4810
      A1=A1/A3                                                                   BEAM4820
      A2=A2/A3                                                                   BEAM4830
      Q=A1/3.0-A2**2/9.0                                                         BEAM4840
      R=(A1*A2-3.0*A0)/6.0-A2**3/27.0                                            BEAM4850
      P=Q**3+R**2                                                                BEAM4860
      IF (P.LT.0.0) GO TO 200                                                    BEAM4870
      P=SQRT (P)                                                                 BEAM4880
      RP=R+P                                                                     BEAM4890
      IF(RP.LT.0.) GO TO 50                                                      BEAM4900
      S1=RP**0.3333333                                                           BEAM4910
      GO TO 60                                                                   BEAM4920
   50 S1=-(-RP)**0.3333333                                                       BEAM4930
   60 RP=R-P                                                                     BEAM4940
      IF(RP.LT.0.) GO TO 70                                                      BEAM4950
      S2=RP**0.3333333                                                           BEAM4960
      GO TO 80                                                                   BEAM4970
   70 S2=-(-RP)**0.3333333                                                       BEAM4980
   80 Z=S1+S2-A2/3.0                                                             BEAM4990
      RETURN                                                                     BEAM5000
  200 P=-P                                                                       BEAM5010
      P=SQRT(P)                                                                  BEAM5020
      SBAR=SQRT(R**2+P**2)                                                       BEAM5030
      COS3=R/SBAR                                                                BEAM5040
      SIN3=P/SBAR                                                                BEAM5050
      W=ATAN(SIN3/COS3)                                                          BEAM5060
      W=W/3.0                                                                    BEAM5070
      C=COS(W)                                                                   BEAM5080
      S=SIN(W)                                                                   BEAM5090
      IF (S.LT.0.)  S=-S                                                         BEAM5100
      SBAR=SBAR**0.3333333                                                       BEAM5110
      Z=2.0*SBAR*C-A2/3.0                                                        BEAM5120
      R=-SBAR*C-A2/3.0+1.732051*SBAR*S                                           BEAM5130
      IF (R.GT.Z) Z=R                                                            BEAM5140
      RETURN                                                                     BEAM5150
      END                                                                        BEAM5160
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      SUBROUTINE DBEAM (AOLD,ANEW,LOAD,NUMDV)                          BEAM5170
C*********************************************************************BEAM5180
C-----DESIGN OF BEAM ELEMENTS                                          BEAM5190
C*********************************************************************BEAM5200
      COMMON/JUNK/JUN(16),LT,LH,L,SIG(27),IDVAR,IFX,FRC,AREA,XINERT,   BEAM5210
     1 ZEE(6),TENS,COMP,SHEAR,KSEC,SECMOD(12),JUN1(227)                BEAM5220
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                    BEAM5230
      DELTA=0.001                                                      BEAM5240
      KMAX=6                                                           BEAM5250
      RMAX=0.                                                          BEAM5260
      AA=AREA                                                          BEAM5270
      IF(IFX.EQ.2) AA=SQRT(AA**3)                                      BEAM5280
      IF(KSEC.GT.1) GO TO 20                                           BEAM5290
C*********************************************************************BEAM5300
C-----SET UP SECTION MODULUS ARRAY SECMOD(I) FOR ABE                   BEAM5310
C     FOUR STRESS POINTS OF X-SECTION AT NODE I                        BEAM5320
C*********************************************************************BEAM5330
      DO 10 I=1,3                                                      BEAM5340
      SECMOD(I)=ZEE(I)*AA                                              BEAM5350
      SECMOD(I+3)=SECMOD(I)                                            BEAM5360
      SECMOD(I+6)=-ZEE(I+3)*AA                                         BEAM5370
   10 SECMOD(I+9)=SECMOD(I+6)                                          BEAM5380
      SECMOD(2)=-SECMOD(2)                                             BEAM5390
      SECMOD(11)=-SECMOD(11)                                           BEAM5400
      GO TO 25                                                         BEAM5410
C*********************************************************************BEAM5420
C-----SET UP SECMOD(I) FOR Z-SECTION OR TUBE                           BEAM5430
C*********************************************************************BEAM5440
   20 DO 15 I=1,3                                                      BEAM5450
      SECMOD(I)=ZEE(I)*AA                                              BEAM5460
      SECMOD(I+3)=-SECMOD(I)                                           BEAM5470
      SECMOD(I+6)=ZEE(I+3)*AA                                          BEAM5480
   15 SECMOD(I+9)=-SECMOD(I+6)                                         BEAM5490
      SECMOD(2)=-SECMOD(2)                                             BEAM5500
      SECMOD(5)=-SECMOD(5)                                             BEAM5510
      IF (KSEC.NE.3) GO TO 25                                          BEAM5520
      SECMOD(8)=0.                                                     BEAM5530
      SECMOD(11)=0.                                                    BEAM5540
C*********************************************************************BEAM5550
C-----OBTAIN AXIAL FORCE X AND MOMENTS XX,YY,ZZ.                       BEAM5560
C     FIRST FOR NODE I, THEN FOR NODE J                                BEAM5570
C*********************************************************************BEAM5580
   25 X=SIG(7)                                                         BEAM5590
      DO 30 N=1,7,6                                                    BEAM5600
      IF (N.EQ.1) GO TO 26                                             BEAM5610
      DO 27 I=1,12                                                     BEAM5620
   27 SECMOD(I)=-SECMOD(I)                                             BEAM5630
   26 XX=SIG(N+3)                                                      BEAM5640
      YY=SIG(N+4)                                                      BEAM5650
      ZZ=SIG(N+5)                                                      BEAM5660
C*********************************************************************BEAM5670
C-----MODIFY MOMENTS FOR TUBE                                          BEAM5680
C*********************************************************************BEAM5690
      IF (KSEC.NE.3) GO TO 40                                          BEAM5700
      YY=SQRT(YY*YY+ZZ*ZZ)                                             BEAM5710
      ZZ=0.                                                            BEAM5720
   40 SAXIAL=X/AREA                                                    BEAM5730
C*********************************************************************BEAM5740
C-----COMPUTE STRESSES AT FOUR STRESS POINTS ON X-SECTION              BEAM5750
C*********************************************************************BEAM5760
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      DO 35 I=1,10,3                                                    BEAM5770
      SSHEAR=0.                                                         BEAM5780
      IF (SECMOD(I).NE.0.) SSHEAR=XX/SECMOD(I)                          BEAM5790
      SBEND=0.                                                          BEAM5800
      IF (SECMOD(I+1).NE.0.) SBEND=YY/SECMOD(I+1)                       BEAM5810
      IF (SECMOD(I+2).NE.0.) SBEND=SBEND+ZZ/SECMOD(I+2)                 BEAM5820
      STOT=SAXIAL+SBEND                                                 BEAM5830
      SSTAR=TENS                                                        BEAM5840
      IF (STOT.LT.0.) SSTAR=-COMP                                       BEAM5850
C*********************************************************************BEAM5860
C-----APPLY REDESIGN EQUATIONS                                          BEAM5870
C*********************************************************************BEAM5880
      IF(IEX.EQ.2) GO TO 81                                             BEAM5890
      R=SQRT((STOT/SSTAR)**2+(SSHEAR/SHEAR)**2)                         BEAM5900
      GO TO 82                                                          BEAM5910
   81 ITEST=1                                                           BEAM5920
      TEST=(SSHEAR/SHEAR)**2-2.0*ABS(SAXIAL*SBEND)/SSTAR**2             BEAM5930
C*********************************************************************BEAM5940
C-----CHECK IF SHEAR STRESS DOMINATES                                   BEAM5950
C*********************************************************************BEAM5960
      IF (TEST.GT.0.) ITEST=2                                           BEAM5970
      KOUNT=0                                                           BEAM5980
      RR=1.                                                             BEAM5990
      R=0.                                                              BEAM6000
      C=-SAXIAL/SSTAR                                                   BEAM6010
   85 GO TO (1,2),ITEST                                                 BEAM6020
    1 AA=(SSHEAR/SHEAR/RR**3)**2                                        BEAM6030
      IF (AA.GT.1.) AA=0.                                               BEAM6040
      A=SQRT(1.0-AA)                                                    BEAM6050
      D=-SBEND/SSTAR                                                    BEAM6060
      GO TO 70                                                          BEAM6070
    2 A=1.                                                              BEAM6080
      D=-((SBEND/SSTAR)**2+(SSHEAR/SHEAR)**2+2.0*SAXIAL*SBEND/(SSTAR**2*BEAM6090
     1SQRT(RR)))                                                        BEAM6100
   70 CALL CBRT(D,C,B,A,R)                                              BEAM6110
C*********************************************************************BEAM6120
C-----CHECK FOR CONVERGENCE                                             BEAM6130
C*********************************************************************BEAM6140
      IF (R.LT.0.000001) GO TO 80                                       BEAM6150
      DR=ABS((R-RR)/R)                                                  BEAM6160
      IF (DR.LT.DELTA.OR.KOUNT.EQ.KMAX) GO TO 80                        BEAM6170
      KOUNT=KOUNT+1                                                     BEAM6180
      RR=R                                                              BEAM6190
      GO TO 85                                                          BEAM6200
   80 IF (ITEST.EQ.1) R=R*R                                             BEAM6210
   82 IF (R.GT.RMAX) RMAX=R                                             BEAM6220
   35 CONTINUE                                                          BEAM6230
   30 CONTINUE                                                          BEAM6240
C*********************************************************************BEAM6250
C-----RECORD NEW DESIGN VARIABLE AND CORRESPONDING LOAD CONDITION       BEAM6260
C*********************************************************************BEAM6270
      AA=RMAX*ADLD(IDVAR)                                               BEAM6280
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                    BEAM6290
      ANEW(IDVAR)=AA                                                    BEAM6300
      LOAD(IDVAR)=L                                                     BEAM6310
   60 CONTINUE                                                          BEAM6320
      RETURN                                                            BEAM6330
      END                                                               BEAM6340
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      SUBROUTINE PLANE(A,MTOT)                                                  PLAN0000
C*************************************************************************PLAN0010
C-----PLANE STRESS ELEMENTS                                                   PLAN0020
C*************************************************************************PLAN0030
      DIMENSION A(MTOT),STRLAB(5)                                             PLAN0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,NEQPLAN0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LB,NEQB,NBLOCK                                 PLAN0060
      COMMON/FM/NU,MW,NS,ND ,FMI(5062)                                        PLAN0070
      COMMON/JUNK/JUN(16),LT,LH,L,SG(20),SIG(7),IDV,IEX,ERC,AREA,XINERT,PLAN0080
     1 DESTNE(60),JUN1(189)                                                   PLAN0090
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                        PLAN0100
      DATA STPLAB/3HGEN,3HL-I,3HJ-K,3HI-J,3HK-L/                              PLAN0110
      NUME=NPAR(2)                                                            PLAN0120
      KODE=NPAR(5)                                                            PLAN0130
      IF(NPAR(1).EQ.0)GO TO 500                                               PLAN0140
      N6=N5+NUMNP                                                             PLAN0150
      NUMMAT=NPAR(3)                                                          PLAN0160
      NUMTC=NPAR(4)                                                           PLAN0170
      GO TO (1,2,3),KODE                                                      PLAN0180
C*************************************************************************PLAN0190
C-----UNIDIRECTIONALLY STIFFENED PANEL                                        PLAN0200
C*************************************************************************PLAN0210
    1 NUMGEO=NPAR(7)                                                          PLAN0220
      N7=N6+NUMMAT                                                            PLAN0230
      N8=N7+NUMMAT                                                            PLAN0240
      N9=N8+NUMGEO*5                                                          PLAN0250
      N10=N9+NUMMAT*NUMTC*8                                                   PLAN0260
      MM=N10-MTOT                                                             PLAN0270
      IF(MM.GT.0) CALL ERROR(MM)                                              PLAN0280
      CALL PLNAX1(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),PLAN0290
     1A(N9),NUMDV,NUMNP,NUMMAT,NUMTC,KODE,NUME,NUMGEO)                        PLAN0300
      RETURN                                                                  PLAN0310
C*************************************************************************PLAN0320
C-----ISOTROPIC PLANE MEMBRANE                                                PLAN0330
C*************************************************************************PLAN0340
    2 N7=N6+NUMMAT                                                            PLAN0350
      N8=N7+NUMMAT                                                            PLAN0360
      N9=N8+NUMMAT*NUMTC*7                                                    PLAN0370
      MM=N9-MTOT                                                              PLAN0380
      IF(MM.GT.0) CALL ERROR(MM)                                              PLAN0390
      CALL PLNAX2(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),PLAN0400
     1 NUMDV,NUMNP,NUMMAT,NUMTC,KODE,NUME)                                    PLAN0410
      RETURN                                                                  PLAN0420
C*************************************************************************PLAN0430
C-----PROVISION FOR SPECIAL MEMBRANE ELEMENT                                  PLAN0440
C*************************************************************************PLAN0450
    3 CALL NOELEM (NPAR(1),KODE,IW)                                           PLAN0460
      RETURN                                                                  PLAN0470
  500 WRITE (IW,2008) KODE                                                    PLAN0480
      DO 800 MM=1,NUME                                                        PLAN0490
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,IB,0)                      PLAN0500
      WRITE (IW,2005) MM,AREA                                                 PLAN0510
      IF(NS.EQ.1) GO TO 800                                                   PLAN0520
      DO 700 L=LT,LH                                                          PLAN0530
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,IB,1)                      PLAN0540
      IF(L.GT.LT) WRITE(IW,2007)                                              PLAN0550
      IT=0                                                                    PLAN0560
      DO 600 KK=1,NS,3                                                        PLAN0570
      IF(KK.GT.1) WRITE(IW,2007)                                              PLAN0580
      DO 520 I=1,3                                                            PLAN0590
```

```
  520 SIG(I)=SG(KK-1+I)                                                  PLAN0600
      II=II+1                                                            PLAN0610
      NP=3                                                               PLAN0620
      IF(II.GT.1) GO TO 530                                              PLAN0630
      NP=6                                                               PLAN0640
      ANG=DESINF(1)                                                      PLAN0650
      IF(ANG.NE.0.) GO TO 540                                            PLAN0660
      DO 550 I=1,3                                                       PLAN0670
  550 SIG(I+3)=SIG(I)                                                    PLAN0680
      GO TO 530                                                          PLAN0690
  540 ANG=ANG/57.2957795                                                 PLAN0700
      SI=SIN(ANG)                                                        PLAN0710
      CO=COS(ANG)                                                        PLAN0720
      SC=SI*CO                                                           PLAN0730
      SI=SI*SI                                                           PLAN0740
      CO=CO*CO                                                           PLAN0750
      X1=SIG(1)*CO+SIG(2)*SI                                             PLAN0760
      X2=2.0*SIG(3)*SC                                                   PLAN0770
      SIG(4)=X1+X2                                                       PLAN0780
      SIG(5)=X1-X2                                                       PLAN0790
      SIG(6)=(SIG(2)-SIG(1))*SC+SIG(3)*(CO-SI)                           PLAN0800
  530 GO TO (4,5,6),KODE                                                 PLAN0810
C*************************************************************************PLAN0820
C-----DESIGN OF STIFFENED MEMBRANE ELEMENT                               PLAN0830
C*************************************************************************PLAN0840
    4 IF(II.GT.1) GO TO 600                                              PLAN0850
      CALL DPLAN1 (A(M1),A(M2),A(M3),NUMDV)                              PLAN0860
      GO TO 600                                                          PLAN0870
C*************************************************************************PLAN0880
C-----DESIGN OF ISOTROPIC MEMBRANE ELEMENT                               PLAN0890
C*************************************************************************PLAN0900
    5 CALL DPLAN2(A(M1),A(M2),A(M3),NUMDV)                               PLAN0910
      GO TO 600                                                          PLAN0920
C*************************************************************************PLAN0930
C-----PROVISION FOR DESIGN OF SPECIAL MEMBRANE ELEMENT                   PLAN0940
C*************************************************************************PLAN0950
    6 CONTINUE                                                           PLAN0960
  600 WRITE (IW,2009) L,STRLAB(II),(SIG(I),I=1,NP)                       PLAN0970
  700 CONTINUE                                                           PLAN0980
  800 CONTINUE                                                           PLAN0990
C*************************************************************************PLAN1000
      RETURN                                                             PLAN1010
 2005 FORMAT(1X,I5,F14.4)                                                PLAN1020
 2008 FORMAT(//45H ANALYSIS OF MEMBRANE ELEMENTS, CONSTRN CODE=,I12//    PLAN1030
     1117H               SHEET     LOAD              /---MEMBRANE FORCES IN PLAN1040
     2LOCAL COORDS---//--MEMBRANE FORCES IN MATERIAL COORDS-/    /        PLAN1050
     3117H ELEMENT    THICKNESS    COND  LOCATION         NXX           NYY PLAN1060
     4          NXY          N11          N22          N12        /)      PLAN1070
 2009 FORMAT(1H+,20X,I5,6X,A3,4X,6E13.4)                                 PLAN1080
 2007 FORMAT(/)                                                          PLAN1090
      END                                                                PLAN1100
```

```
      SUBROUTINE FLAW(BETA)                                              PLAN1110
C*********************************************************************PLAN1120
C-----STRESS /STRAIN RELATION MATRIX                                     PLAN1130
C*********************************************************************PLAN1140
      IMPLICIT REAL*8 (A-H,O-Z)                                          PLAN1150
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),D(3,3),XX(4),YY(4),ZZ(4),TMP(4),PLAN1160
     1 ALP(3),TT(3),PRESS,REFT,NS,JUN1,T(3,3),DD(3,3),JUN(148)           PLAN1170
      IF (BETA.EQ.0.0) GO TO 500                                         PLAN1180
      ANG=BETA/57.2957795                                                PLAN1190
      SS=DSIN(ANG)                                                       PLAN1200
      CO=DCOS(ANG)                                                       PLAN1210
      C2=CO*CO                                                           PLAN1220
      S2=SS*SS                                                           PLAN1230
      SC=SS*CO                                                           PLAN1240
C*********************************************************************PLAN1250
C-----SET D FOR SIG(O)=D*SIG(G)                                          PLAN1260
C*********************************************************************PLAN1270
      T(1,1)=C2                                                          PLAN1280
      T(1,2)=S2                                                          PLAN1290
      T(1,3)=2.*SC                                                       PLAN1300
      T(2,1)=S2                                                          PLAN1310
      T(2,2)=C2                                                          PLAN1320
      T(2,3)=-2.*SC                                                      PLAN1330
      T(3,1)=-SC                                                         PLAN1340
      T(3,2)=SC                                                          PLAN1350
      T(3,3)=C2-S2                                                       PLAN1360
      DO 300 I=1,3                                                       PLAN1370
      DO 300 J=1,3                                                       PLAN1380
      SUM=0.                                                             PLAN1390
      DO 280 M=1,3                                                       PLAN1400
  280 SUM=SUM+T(M,I)*D(M,J)                                              PLAN1410
  300 DD(I,J)=SUM                                                        PLAN1420
      DO 350 I=1,3                                                       PLAN1430
      DO 350 J=1,3                                                       PLAN1440
      SUM=0.                                                             PLAN1450
      DO 330 M=1,3                                                       PLAN1460
  330 SUM=SUM+DD(I,M)*T(M,J)                                             PLAN1470
      D(I,J)=SUM                                                         PLAN1480
  350 D(J,I)=SUM                                                         PLAN1490
      A1=ALP(1)                                                          PLAN1500
      A2=ALP(2)                                                          PLAN1510
      ALP(1)=C2*A1+S2*A2                                                 PLAN1520
      ALP(2)=S2*A1+C2*A2                                                 PLAN1530
      ALP(3)=2.0*SC*(A1-A2)                                              PLAN1540
  500 CALL PDSINV(D)                                                     PLAN1550
      DO 670 I=1,3                                                       PLAN1560
      TT(I)=0.                                                           PLAN1570
      DO 670 M=1,3                                                       PLAN1580
  670 TT(I)=TT(I)+D(I,M)*ALP(M)                                          PLAN1590
      RETURN                                                             PLAN1600
      END                                                                PLAN1610
```

```
      SUBROUTINE QUAD(RHO,THICK)                                        PLAN1620
C*********************************************************************PLAN1630
C-----FORM ELEMENT MATRICES                                             PLAN1640
C*********************************************************************PLAN1650
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN1660
      COMMON/ELPAR/NPAR(14),IELP(19)                                    PLAN1670
      COMMON/EM/LM(12),S(12,12),P1(12,4),P2(12,4),XM(12),ST(15,12),     PLAN1680
     1 TT(15,4),BB(12,12),EM1(1891)                                     PLAN1690
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),D(3,3),X (4),Y (4),Z (4),TM (4),PLAN1700
     1 ALP(3),TTT(3),PRESS,REFT,NS,JUNK  ,BR(4),ZZ(4),PP1(12),          PLAN1710
     2 U(4),V(4),W(4),H(6),HR(6),HZ(6),FAC,G(4),F(4),JUN(66)            PLAN1720
      DIMENSION SS(2),SSS(5),TTT(5),IVECT(4),JVECT(4),EMM(636)          PLAN1730
      EQUIVALENCE (S,EMM)                                               PLAN1740
      DATA SS/-0.5773502691896 3,0.5773502691896 3/                     PLAN1750
      DATA SSS/0.,-1.,1.,0.,0./, TTT/0.,0.,0.,-1.,1./                   PLAN1760
      DATA IVECT/4,2,1,3/,JVECT/1,3,2,4/                                PLAN1770
      DO 10 I=1,636                                                     PLAN1780
   10 EMM(I)=0.                                                         PLAN1790
      DO 20 I=1,12                                                      PLAN1800
   20 PP1(I)=0.                                                         PLAN1810
C*********************************************************************PLAN1820
C-----COMPUTE ELEMENT AXES SYSTEM AND CORNER COORDINATES                PLAN1830
C*********************************************************************PLAN1840
      CALL VECTOR(U,X(1),Y(1),Z(1),X(2),Y(2),Z(2))                      PLAN1850
      CALL VECTOR(F,X(1),Y(1),Z(1),X(4),Y(4),Z(4))                      PLAN1860
      CALL CROSS(U,F,W)                                                 PLAN1870
      CALL CROSS(W,U,V)                                                 PLAN1880
      CALL VECTOR(G,X(1),Y(1),Z(1),X(3),Y(3),Z(3))                      PLAN1890
      RR(1)=0.0                                                         PLAN1900
      ZZ(1)=0.0                                                         PLAN1910
      RR(2)=U(4)                                                        PLAN1920
      ZZ(2)=0.0                                                         PLAN1930
      RR(3)=G(4)*DOT(G,U)                                               PLAN1940
      ZZ(3)=G(4)*DOT(G,V)                                               PLAN1950
      RR(4)=F(4)*DOT(F,U)                                               PLAN1960
      ZZ(4)=F(4)*DOT(F,V)                                               PLAN1970
C*********************************************************************PLAN1980
C-----FORM UNIT STIFFNESS MATRIX  , THERMAL LOAD VECTOR AND MASS MATRIX PLAN1990
C*********************************************************************PLAN2000
      DO 500 II=1,2                                                     PLAN2010
      DO 500 JJ=1,2                                                     PLAN2020
      CALL FORMB(SS(II),SS(JJ),BB)                                      PLAN2030
      FTP=H(1)*TM(1)+H(2)*TM(2)+H(3)*TM(3)+H(4)*TM(4)-REFT              PLAN2040
      DO 400 J=1,12                                                     PLAN2050
      B1=BB(1,J)*FAC                                                    PLAN2060
      B2=BB(2,J)*FAC                                                    PLAN2070
      B3=BB(3,J)*FAC                                                    PLAN2080
      D1=D(1,1)*B1+D(1,2)*B2+D(1,3)*B3                                  PLAN2090
      D2=D(2,1)*B1+D(2,2)*B2+D(2,3)*B3                                  PLAN2100
      D3=D(3,1)*B1+D(3,2)*B2+D(3,3)*B3                                  PLAN2110
      PP1(J)=PP1(J)+FTP*(D1*ALP(1)+D2*ALP(2)+D3*ALP(3))                 PLAN2120
      DO 400 I=J,12                                                     PLAN2130
      S(I,J)=S(I,J)+BB(1,I)*D1+BB(2,I)*D2+BB(3,I)*D3                    PLAN2140
  400 S(J,I)=S(I,J)                                                     PLAN2150
      DO 450 I=1,4                                                      PLAN2160
  450 XM(I)=XM(I)+FAC* THICK*H(I)                                       PLAN2170
  500 CONTINUE                                                          PLAN2180
C*********************************************************************PLAN2190
C-----FORM STRESS DISPLACEMENT MATRIX                                   PLAN2200
C*********************************************************************PLAN2210
```

```
      LL=NS/3                                                          PLAN2220
      DO 530 L=1,LL                                                    PLAN2230
      CALL FORMB(SSS(L),TTT(L),BB)                                     PLAN2240
      FTP=H(1)*TM(1)+H(2)*TM(2)+H(3)*TM(3)+H(4)*TM(4)-REFT             PLAN2250
      DO 530 II=1,3                                                    PLAN2260
      I=II+3*(L-1)                                                     PLAN2270
      TT(I,4)=-TTI(II)*FTP                                             PLAN2280
      DO 530 J=1,12                                                    PLAN2290
      DO 530 K=1,3                                                     PLAN2300
  530 ST(I,J)=ST(I,J)+D(II,K)*BB(K,J)                                  PLAN2310
C**********************************************************************PLAN2320
C-----ELIMINATE EXTRA DEGREES OF FREEDOM                               PLAN2330
C**********************************************************************PLAN2340
      IF ( IX(3) .EQ. IX(4) ) GO TO 560                                PLAN2350
      IF(NPAR(6).NE.0) GO TO 560                                       PLAN2360
      DO 550 NN=1,4                                                    PLAN2370
      L=12-NN                                                          PLAN2380
      K=L+1                                                            PLAN2390
      C=PP1(K)/S(K,K)                                                  PLAN2400
      DO 535 J=1,NS                                                    PLAN2410
  535 TT(J,4)=TT(J,4)+C*ST(J,K)                                        PLAN2420
      DO 550 I=1,L                                                     PLAN2430
      C=S(I,K)/S(K,K)                                                  PLAN2440
      PP1(I)=PP1(I)-C*PP1(K)                                           PLAN2450
      DO 540 J=1,NS                                                    PLAN2460
  540 ST(J,I)=ST(J,I)-C*ST(J,K)                                        PLAN2470
      DO 550 J=1,L                                                     PLAN2480
  550 S(I,J)=S(I,J)-C*S(K,J)                                           PLAN2490
C**********************************************************************PLAN2500
C-----ROTATE STRESS-DISPLACEMENT TRANSFORMATION TO GIVE STRESSES        PLAN2510
C     NORMAL AND PARALLEL TO SIDES - SIMILARLY ROTATE INITIAL STRESSES  PLAN2520
C**********************************************************************PLAN2530
  560 NSET=LL-1                                                        PLAN2540
      IF ( NSET .LE. 0 ) GO TO 730                                     PLAN2550
      DO 720 L=1,NSET                                                  PLAN2560
      IV=IVECT(L)                                                      PLAN2570
      JV=JVECT(L)                                                      PLAN2580
      CALL VECTOR(G,RR(IV),ZZ(IV),0.000,RR(JV),ZZ(JV),0.000)           PLAN2590
      S2=G(1)*G(1)                                                     PLAN2600
      C2=G(2)*G(2)                                                     PLAN2610
      SC=-G(1)*G(2)                                                    PLAN2620
      I1=3*L+1                                                         PLAN2630
      I2=I1+1                                                          PLAN2640
      I3=I1+2                                                          PLAN2650
      T1=TT(I1,4)                                                      PLAN2660
      T2=TT(I2,4)                                                      PLAN2670
      T3=TT(I3,4)                                                      PLAN2680
      T4=2.0*SC*T3                                                     PLAN2690
      TT(I1,4)=C2*T1+S2*T2+T4                                          PLAN2700
      TT(I2,4)=S2*T1+C2*T2-T4                                          PLAN2710
      TT(I3,4)=SC*(T2-T1)+(C2-S2)*T3                                   PLAN2720
      DO 710 J=1,8                                                     PLAN2730
      B1=ST(I1,J)                                                      PLAN2740
      B2=ST(I2,J)                                                      PLAN2750
      B3=ST(I3,J)                                                      PLAN2760
      B4=2.0*SC*B3                                                     PLAN2770
      ST(I1,J)=C2*B1+S2*B2+B4                                          PLAN2780
      ST(I2,J)=S2*B1+C2*B2-B4                                          PLAN2790
  710 ST(I3,J)=SC*(B2-B1)+(C2-S2)*B3                                   PLAN2800
  720 CONTINUE                                                         PLAN2810
```

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  730 IF(NPAR(5).NE.2) GO TO 150                                        PLAN2820
C*************************************************************************PLAN2830
C-----CALCULATE PRESSURE LOADS ON I-J FACE IN GLOBAL COORDINATES         PLAN2840
C*************************************************************************PLAN2850
      XX=0.5*PPRESS*RR(2)                                               PLAN2860
      DO 185 I=1,3                                                      PLAN2870
      II=(I-1)*4+1                                                      PLAN2880
      DO 185 L=1,4                                                      PLAN2890
      P2(II,L)=XX*V(I)*EMUL(L,2)                                        PLAN2900
  185 P2(II+1,L)=P2(II,L)                                               PLAN2910
C*************************************************************************PLAN2920
C-----COORDINATE TRANSFORMATION                                         PLAN2930
C*************************************************************************PLAN2940
  150 DO 190 I=1,3                                                      PLAN2950
      DO 190 K=1,4                                                      PLAN2960
      KK=4*(I-1)+K                                                      PLAN2970
      DO 180 J=1,3                                                      PLAN2980
      DO 180 L=1,4                                                      PLAN2990
      LL=4*(J-1)+L                                                      PLAN3000
  180 BB(KK,LL)=U(I)*(S(K  ,L)*U(J)+S(K  ,L+4)*V(J))+                   PLAN3010
     1          V(I)*(S(K+4,L)*U(J)+S(K+4,L+4)*V(J))                   PLAN3020
      X1=U(I)*PP1(K)+V(I)*PP1(K+4)                                      PLAN3030
      DO 190 L=1,4                                                      PLAN3040
  190 P1(KK,L)=X1*EMUL(L,1)                                             PLAN3050
      DO 195 I=1,12                                                     PLAN3060
      DO 195 J=1,12                                                     PLAN3070
      S(I,J)=BB(I,J)                                                    PLAN3080
  195 S(J,I)=S(I,J)                                                     PLAN3090
      DO 210 K=1,NS                                                     PLAN3100
      DO 200 L=1,4                                                      PLAN3110
      DO 200 J=1,3                                                      PLAN3120
      LL=4*(J-1)+L                                                      PLAN3130
  200 PP1(LL)=ST(K,L)*U(J)+ST(K,L+4)*V(J)                               PLAN3140
      DO 210 J=1,12                                                     PLAN3150
  210 ST(K,J)=PP1(J)                                                    PLAN3160
      DO 220 I=1,4                                                      PLAN3170
      XX=XM(I)*RHO                                                      PLAN3180
      DO 220 L=1,4                                                      PLAN3190
      P1(I  ,L)=P1(I  ,L)+XX*EMUL(L,3)                                  PLAN3200
      P1(I+4,L)=P1(I+4,L)+XX*EMUL(L,4)                                  PLAN3210
  220 P1(I+8,L)=P1(I+8,L)+XX*EMUL(L,5)                                  PLAN3220
      DO 600 L=1,4                                                      PLAN3230
      DO 600 I=1,NS                                                     PLAN3240
  600 TT(I,L)=TT(I,4)*EMUL(L,1)                                         PLAN3250
      RETURN                                                            PLAN3260
      END                                                               PLAN3270
```

```
      SUBROUTINE FORMB(S,T,B)                                                PLAN3280
C***********************************************************************PLAN3290
C-----FORM SHAPE-FUNCTION DERIVATIVES AND STRAIN-DISPLACEMENT  MATRIX   PLAN3300
C***********************************************************************PLAN3310
      IMPLICIT REAL*8 (A-H,O-Z)                                              PLAN3320
      DIMENSION B(12,12),II(6),JJ(6)                                         PLAN3330
      COMMON/JUNK/IE(4),IX(4),EMOD(4,5),D(3,3),X (4),Y (4),Z (4),TMP(4),PLAN3340
     1 ALP(3),III(3),PRESS,REFT,NS,JUNK  ,RR(4),ZZ(4),PPI(12),              PLAN3350
     2 U(4),V(4),W(4),H(6),HR(6),HZ(6),XJ,HS(6),HT(6),JUN(58)               PLAN3360
      DATA II/1,2,3,4,9,10/,JJ/5,6,7,8,11,12/                                PLAN3370
      SM=1.0-S                                                               PLAN3380
      SP=1.0+S                                                               PLAN3390
      TM=1.0-T                                                               PLAN3400
      TP=1.0+T                                                               PLAN3410
      H(1)=SM*TM*.25                                                         PLAN3420
      H(2)=SP*TM*.25                                                         PLAN3430
      H(3)=SP*TP*.25                                                         PLAN3440
      H(4)=SM*TP*.25                                                         PLAN3450
      H(5)=(1.0-S*S)                                                         PLAN3460
      H(6)=(1.0-T*T)                                                         PLAN3470
      HS(1)=-TM*.25                                                          PLAN3480
      HS(2)=-HS(1)                                                           PLAN3490
      HS(3)=TP*.25                                                           PLAN3500
      HS(4)=-HS(3)                                                           PLAN3510
      HS(5)=-2.*S                                                            PLAN3520
      HS(6)=0.0                                                              PLAN3530
      HT(1)=-SM*.25                                                          PLAN3540
      HT(2)=-SP*.25                                                          PLAN3550
      HT(3)=-HT(2)                                                           PLAN3560
      HT(4)=-HT(1)                                                           PLAN3570
      HT(5)=0.0                                                              PLAN3580
      HT(6)=-2.*T                                                            PLAN3590
      PZT=HT(3)*ZZ(3)+HT(4)*ZZ(4)                                            PLAN3600
      PZS=HS(3)*ZZ(3)+HS(4)*ZZ(4)                                            PLAN3610
      PRS=HS(2)*RR(2)+HS(3)*RR(3)+HS(4)*RR(4)                                PLAN3620
      PRT=HT(2)*RR(2)+HT(3)*RR(3)+HT(4)*RR(4)                                PLAN3630
      IF(DABS(ZZ(3)-ZZ(4)).LE.1.0E-10) PZS=0.                                PLAN3640
      IF(DABS(RR(2)-RR(3)).LE.1.0E-10.AND.DABS(RR(4)).LE.1.0E-10) PRT=0.PLAN3650
      XJ=PRS*PZT-PRT*PZS                                                     PLAN3660
      PSR=PZT/XJ                                                             PLAN3670
      PTR=-PZS/XJ                                                            PLAN3680
      PSZ=-PRT/XJ                                                            PLAN3690
      PTZ=PRS/XJ                                                             PLAN3700
      DO 100 I=1,6                                                           PLAN3710
      HR(I)=PSR*HS(I)+PTR*HT(I)                                              PLAN3720
  100 HZ(I)=PSZ*HS(I)+PTZ*HT(I)                                              PLAN3730
C***********************************************************************PLAN3740
C-----FORM STRAIN DISPLACEMENT MATRIX                                   PLAN3750
C***********************************************************************PLAN3760
      DO 200 K=1,6                                                           PLAN3770
      I=II(K)                                                                PLAN3780
      J=JJ(K)                                                                PLAN3790
      B(1,I)=HR(K)                                                           PLAN3800
      B(2,J)=HZ(K)                                                           PLAN3810
      B(3,I)=HZ(K)                                                           PLAN3820
  200 B(3,J)=HR(K)                                                           PLAN3830
      RETURN                                                                 PLAN3840
      END                                                                    PLAN3850.
```

```
      SUBROUTINE POSINV(A)                                                  PLAN3860
C*********************************************************************PLAN3870
C                                                                       PLAN3880
C*********************************************************************PLAN3890
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN3900
      DIMENSION A(3,3)                                                  PLAN3910
      DO 200 N=1,3                                                      PLAN3920
      D=A(N,N)                                                          PLAN3930
      DO 100 J=1,3                                                      PLAN3940
  100 A(N,J)=-A(N,J)/D                                                  PLAN3950
      DO 150 I=1,3                                                      PLAN3960
      IF(N-I) 110,150,110                                               PLAN3970
  110 DO 140 J=1,3                                                      PLAN3980
      IF(N-J) 120,140,120                                               PLAN3990
  120 A(I,J)=A(I,J)+A(I,N)*A(N,J)                                       PLAN4000
  140 CONTINUE                                                          PLAN4010
  150 A(I,N)=A(I,N)/D                                                   PLAN4020
      A(N,N)=1.0/D                                                      PLAN4030
  200 CONTINUE                                                          PLAN4040
      RETURN                                                            PLAN4050
      END                                                               PLAN4060
```

```
      SUBROUTINE PLNAX1(UWT,ID,X,Y,Z,T,NTC,WT,PGEO,PMAT,NUMDV,NUMNP,    PLAN4070
     1NUMMAT,NUMTC,KODE,NUME,NUMGEO)                                    PLAN4080
C*********************************************************************PLAN4090
C-----STIFFENED MEMBRANE ELEMENT                                        PLAN4100
C*********************************************************************PLAN4110
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN4120
      REAL*4 UWT,X,Y,Z,T,PGEO,WT,PMAT,BE1,E4,E5,E6,E7,SBC,PBC,GBC,FRC   PLAN4130
      DIMENSION UWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),      PLAN4140
     1 T(NUMNP),NTC(NUMMAT),WT(NUMMAT),PGEO(NUMMAT,5),                  PLAN4150
     2 PMAT(NUMTC,8,NUMMAT)                                             PLAN4160
      COMMON/EM/LM(12),S(12,12),P1(12,4),P2(12,4),XM(12),ST(15,12),     PLAN4170
     1 TT(15,4),BB(12,12),EM1(189)                                      PLAN4180
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),C(3,3),XX(4),YY(4),ZZ(4),TMP(4),PLAN4190
     1 ALP(3),TTT(3),PRESS,BEE1,NS,JUN1,X1,X2,X3,X4,Y1,Y2,Y3,Y4,EE(7),  PLAN4200
     2 JUN(154)                                                         PLAN4210
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                  PLAN4220
C*********************************************************************PLAN4230
C-----CONTROL INFORMATION                                               PLAN4240
C*********************************************************************  PLAN4250
      MU=1                                                              PLAN4260
      MV=1                                                              PLAN4270
      MD=12                                                             PLAN4280
      MW=1                                                              PLAN4290
      MT=9                                                              PLAN4300
      IEX=3                                                             PLAN4310
      WRITE(IW,2000)NUME,KODE,NUMMAT,NUMGEO,NUMTC                       PLAN4320
      WRITE(IW,2019)                                                    PLAN4330
      DO 60 M=1,NUMMAT                                                  PLAN4340
      READ(IR,1010) N,NTC(N),WT(N)                                      PLAN4350
      IF(NTC(N).LE.0) NTC(N)=1                                          PLAN4360
      WRITE(IW,2020) N,NTC(N),WT(N)                                     PLAN4370
C*********************************************************************PLAN4380
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                         PLAN4390
C*********************************************************************PLAN4400
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```
      NT=NTC(N)                                                          PL AN4410
      READ(IR,1005) ((PMAT(I,J,N),J=1,8),I=1,NT)                         PL AN4420
      DO 10 I=1,NT                                                       PL AN4430
      IF(PMAT(I,6,N).LE.0.) PMAT(I,6,N)=PMAT(I,5,N)                      PL AN4440
      IF(PMAT(I,7,NT).LE.0.) PMAT(I,7,N)=PMAT(I,5,N)*0.577               PL AN4450
      IF(PMAT(I,8,NT).LE.0.) PMAT(I,8,N)=PMAT(I,6,N)                     PL AN4460
   10 CONTINUE                                                           PL AN4470
   60 WRITE(IW,2010) ((PMAT(I,J,N),J=1,8),I=1,NT)                        PL AN4480
C*********************************************************************PL AN4490
C-----GEOMETRIC PROPERTY CARDS                                           PL AN4500
C*********************************************************************PL AN4510
      WRITE(IW,2011)                                                     PL AN4520
      DO 70 I=1,NUMGEO                                                   PL AN4530
      READ(IR,1006) N,TH,W,SA,SI,D,WF                                    PL AN4540
      IF(WF.LE.0.) WF=W                                                  PL AN4550
      PGEO(N,1)=1.0+SA/(W*TH)                                            PL AN4560
      PGEO(N,2)=W/TH                                                     PL AN4570
      PGEO(N,3)=WF/TH                                                    PL AN4580
      DB=SA*D/(W*TH+SA)                                                  PL AN4590
      BI=W*TH**3/12.0+W*TH*DB*DB+SI+SA*(D/PGEO(N,1))**2                  PL AN4600
      PGEO(N,4)=BI/TH**4                                                 PL AN4610
      C1=12.0*SI*0.925/(W*TH**3)                                         PL AN4620
      C2=SA*D*D/SI                                                       PL AN4630
      C3=1.0+C2/(0.88*PGEO(N,1)+0.12)                                    PL AN4640
      PGEO(N,5)=2.0*PGEO(N,2)**2*(DSQRT(1.0+C1*C3)+1.0)                  PL AN4650
   70 WRITE(IW,2012) N,TH,W,SA,SI,D,WF                                   PL AN4660
C*********************************************************************PL AN4670
C-----ELEMENT LOAD MULTIPLIERS                                           PL AN4680
C*********************************************************************PL AN4690
      DO 131 I=1,4                                                       PL AN4700
      READ(IR,1002) EMUL(I,1),(EMUL(I,J),J=3,5)                          PL AN4710
  131 EMUL(I,2)=0.                                                       PL AN4720
      WRITE(IW,2004)(EMUL(I,1),(EMUL(I,J),J=3,5) ,I=1,4)                 PL AN4730
C*********************************************************************PL AN4740
C-----ELEMENT CARDS                                                      PL AN4750
C*********************************************************************PL AN4760
      WRITE (6,2002)                                                     PL AN4770
      N=1                                                                PL AN4780
  130 READ(IR,1003) IEL,IF,IMAT,IDV,FRC,REFT,AA,AR,BETA,EFC,NS,INC       PL AN4790
      IF (FRC.LE.0.) FRC=1.                                              PL AN4800
      IF (EFC.LE.0) EFC=1.                                               PL AN4810
      IF(INC.EQ.0) INC=1                                                 PL AN4820
      IF(NS.EQ.0) NS=3                                                   PL AN4830
      IF(NS.LT.3) NS=1                                                   PL AN4840
      IF( (IF(3) .EQ. IF(4)) .AND. (NS.EQ. 15) ) NS=12                   PL AN4850
      ANG=BETA/57.2957795                                                PL AN4860
      RHO=WT(IMAT)                                                       PL AN4870
      THICK=PGEO(IMAT,1)                                                 PL AN4880
      REF=REFTA                                                          PL AN4890
      KK=INC*(IEL-N)                                                     PL AN4900
      DO 142 I=1,4                                                       PL AN4910
  142 IX(I)=IF(I)-KK                                                     PL AN4920
      DO 500 NEL=N,IEL                                                   PL AN4930
      TEMP=0.                                                            PL AN4940
      DO 501 I=1,4                                                       PL AN4950
      II=IX(I)                                                           PL AN4960
      TEMP=TEMP+T(II)*0.25                                               PL AN4970
      XX(I)=X(II)                                                        PL AN4980
      YY(I)=Y(II)                                                        PL AN4990
  501 ZZ(I)=Z(II)                                                        PL AN5000
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C*************************************************************************PLAN5010
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE    PLAN5020
C*************************************************************************PLAN5030
      CALL INTERP(PMAT,FF,NUMTC,NUMMAT,8,7,NTC(IMAT),IMAT,TEMP)          PLAN5040
      E4=FF(4)                                                           PLAN5050
      E5=FF(5)                                                           PLAN5060
      E6=FF(6)                                                           PLAN5070
      E7=FF(7)                                                           PLAN5080
      C1=FF(1)*9.8696                                                    PLAN5090
      C2=C1/13.0*(1.0-FF(2)**2))                                         PLAN5100
C*************************************************************************PLAN5110
C-----FORM CONSTITUTIVE LAW AND COMPUTE THERMAL STRESSES                 PLAN5120
C*************************************************************************PLAN5130
      DO 265 I=1,3                                                       PLAN5140
      DO 265 J=1,3                                                       PLAN5150
  265 C(I,J)=0.                                                          PLAN5160
      C(2,2)=1.0/FF(1)                                                   PLAN5170
      C(1,1)=C(2,2)/THICK                                                PLAN5180
      C(1,2)=-C(1,1)*FF(2)                                               PLAN5190
      C(2,1)=C(1,2)                                                      PLAN5200
      C(3,3)=C(2,2)*2.0*(1.0+FF(2))                                      PLAN5210
      ALP(1)=FF(3)                                                       PLAN5220
      ALP(2)=FF(3)                                                       PLAN5230
      ALP(3)=0.                                                          PLAN5240
      CALL PLAW(BETA)                                                    PLAN5250
C*************************************************************************PLAN5260
C-----FORM ELEMENT LOCATION MATRIX AND COMPUTE ELEMENT MATRICES          PLAN5270
C*************************************************************************PLAN5280
      DO 170 I=1,4                                                       PLAN5290
      II=IX(I)                                                           PLAN5300
      TMP(I)=T(II)                                                       PLAN5310
      LM(I)=ID(II,1)                                                     PLAN5320
      LM(I+4)=ID(II,2)                                                   PLAN5330
  170 LM(I+8)=ID(II,3)                                                   PLAN5340
      CALL QUAD(RHO,THICK)                                               PLAN5350
      AREA=XM(1)+XM(2)+XM(3)+XM(4)                                       PLAN5360
      WT(IDV)=WT(IDV)+AREA*RHO*FRC                                       PLAN5370
C*************************************************************************PLAN5380
C-----COMPUTE ELEMENT DESIGN INFORMATION                                 PLAN5390
C*************************************************************************PLAN5400
      IF(AA.LE.0)AA=.5*( (X2+X3-X1-X4)*DCOS(ANG)-(Y2+Y3-Y1-Y4)*DSIN(ANG))PLAN5410
      IF(AB.LE.0)AB=.5*((X3+X4-X1-X2)*DSIN(ANG)+(Y3+Y4-Y1-Y2)*DCOS(ANG))PLAN5420
      SBC=C1*EFC*PGEO(IMAT,4)/(AA*AA*PGEO(IMAT,2))                       PLAN5430
      PBC=C2*THICK/PGEO(IMAT,3)**2                                       PLAN5440
      GBC=C2*0.25*PGEO(IMAT,5)/AB**4                                     PLAN5450
C*************************************************************************PLAN5460
C-----CALCULATE BANDWIDTH AND WRITE ELEMENT INFO. ON TAPES               PLAN5470
C*************************************************************************PLAN5480
      NN=NS*ND*NU                                                        PLAN5490
      CALL REARAN (ST,ST,15,12,1,NS,ND,NU,NN)                            PLAN5500
      NN=NS*4*NW                                                         PLAN5510
      CALL REARAN(TT,TT,15,4,1,NS,4,NW,NN)                               PLAN5520
      CALL CALBAN(NDIF,LM,S,P1,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,FRC)         PLAN5530
      WRITE (IB) NI,BET ,E4,E5,E6,E7,PGEO(IMAT,1),SBC,PBC,GBC            PLAN5540
      WRITE(IW,2003) NEL,IX,IMAT,IDV,FRC,REFT,AA,AB,BETA,EFC,NS,NDIF     PLAN5550
      DO 450 I=1,4                                                       PLAN5560
  450 IX(I)=IX(I)+INC                                                    PLAN5570
  500 CONTINUE                                                           PLAN5580
      N=IEL+1                                                            PLAN5590
      IF(N.LE.NUME) GO TO 130                                            PLAN5600
```

```
      RETURN                                                                PLAN5610
 1002 FORMAT(4E10.0)                                                        PLAN5620
 1003 FORMAT(7I5,5X,4E10.0/2E10.0,2I5)                                      PLAN5630
 1005 FORMAT (8E10.0)                                                       PLAN5640
 1006 FORMAT(I5,6E10.0)                                                     PLAN5650
 1010 FORMAT(2I5, E10.0)                                                    PLAN5660
 2000 FORMAT(43H1NUMBER OF MEMBRANE ELEMENTS                =,I5/         PLAN5670
     1       44H CONSTRUCTION KODE                          =,I5/         PLAN5680
     2       44H NUMBER OF MATERIALS                        =,I5/         PLAN5690
     3       44H NUMBER OF GEOMETRIC PROPERTIES             =,I5/         PLAN5700
     4       44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5)          PLAN5710
 2002 FORMAT(// 23H PROCESSED ELEMENT DATA//                                PLAN5720
     1121H ELEMT/-------NODES------//-ID NOS-/     DES VAR   REFERENCE    PLAN5730
     2MAX LENGTH      WIDTH      ANGLE TO   END FIXITY  PRNT  BAND       / PLAN5740
     3121H NUMBR     I     J     K     L   MAT    DV     FRACTION      TEMP     PLAN5750
     4OF STIFFNR  OF ELEMENT  PRINC DIRN     COEFFT     CODE  WDTH       /)PLAN5760
 2003 FORMAT(1X,7I5,6E12.4,2I6)                                             PLAN5770
 2004 FORMAT(23H ELEMENT LOAD FRACTIONS /59H LOAD CASE TEMPERATURE  X-DIPLAN5780
     1RECTION Y-DIRECTION Z-DIRECTION /9X,1HA,4E12.3/                       PLAN5790
     2 9X,1HB,4E12.3/ 9X,1HC,4E12.3/ 9X,1HD,4E12.3)                         PLAN5800
 2010 FORMAT(1H+,25X,8E13.4/(26X,8E14.4))                                   PLAN5810
 2011 FORMAT(/91H GEOMETRY      SHEET       SPACING OF  /----------STIFFENPLAN5820
     1ER PROPERTIES----------/     WIDTH OF /                               PLAN5830
     2 91H  NUMBER    THICKNESS      STIFFENERS        AREA          INERTIA PLAN5840
     4    DIST OF COG       SHEET     )                                    PLAN5850
 2012 FORMAT(1X,I5,6E14.4)                                                  PLAN5860
 2019 FORMAT(// 25H MATERIAL PROPERTY CARDS   /                             PLAN5870
     1/)25H  MATL  NO OF   SPECIFIC                        YOUNGS       POIPLAN5880
     2SSONS      COEFFT OF    /-----------ALLOWABLE STRESSES----------/   PLAN5890
     3/121H  NBR   TEMP      WEIGHT       TEMPERATURE      MODULUS        RPLAN5900
     4ATIO      THERM EXPN        TENS     COMP     SHEAR    CRIPLING      /)PLAN5910
 2020 FORMAT(1X,I4,I6,2X,E14.4)                                             PLAN5920
      END                                                                   PLAN5930
```

```
      SUBROUTINE DPLAN1 (ADLD,ANEW,LOAD,NUMDV)                              PLAN5940
C*************************************************************************PLAN5950
C-----DESIGN OF STIFFENED MEMBRANE ELEMENT                                  PLAN5960
C*************************************************************************PLAN5970
      DIMENSION ADLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                         PLAN5980
      COMMON/JUNK/JUN(16),LT,LH,L,SG(20),SIG(7),IDVAR,IEX,ERC,AREA,         PLAN5990
     1 XINERT,BETA,TENS,COMP,SHEAR,CRUSH,TAU,SBC,PBC,GBC,JUN1(240)          PLAN6000
      PX=SIG(4)                                                             PLAN6010
      PY=SIG(5)                                                             PLAN6020
      PXY=SIG(6)                                                            PLAN6030
C*************************************************************************PLAN6040
C-----FULLY STRESSED DESIGN                                                 PLAN6050
C*************************************************************************PLAN6060
      P1=COMP*TAU*AREA                                                      PLAN6070
      P2=COMP*AREA                                                          PLAN6080
      P12=SHEAR*AREA                                                        PLAN6090
      IF (PX.GT.0.0) P1=TENS*TAU*AREA                                       PLAN6100
      IF (PY.GT.0.0) P2=TENS*AREA                                           PLAN6110
      RMAX=(PX/P1)**2+(PY/P2)**2-(PX/P1)*(PY/P2)+(PXY/P12)**2               PLAN6120
      RMAX=SQRT(RMAX)                                                       PLAN6130
      IF (PX.GE.0.0) GO TO 100                                              PLAN6140
C*************************************************************************PLAN6150
C-----STIFFENER FAILURE                                                     PLAN6160
```

```
C*************************************************************************PLAN6170
      P=-PX                                                                PLAN6180
      PF=SRC*XINERT                                                        PLAN6190
      AA=P/PF                                                              PLAN6200
      R=1.0/IFX                                                            PLAN6210
      R=AA**R                                                              PLAN6220
      IF (R.GT.RMAX) RMAX=R                                                PLAN6230
      P1=CRUSH*TAU*AREA                                                    PLAN6240
      P2=0.5*P1                                                            PLAN6250
      CALL JOHNS (IFX,P,P1,P2,PF,R)                                        PLAN6260
      IF (R.GT.RMAX) RMAX=R                                                PLAN6270
C*************************************************************************PLAN6280
C-----SHEET BUCKLING BETWEEN STIFFENERS                                    PLAN6290
C*************************************************************************PLAN6300
  100 PX=-PX                                                               PLAN6310
      PY=-PY                                                               PLAN6320
      AA=PX+4.0*PY/TAU                                                     PLAN6330
      BB=1.495*PXY/TAU                                                     PLAN6340
      R=0.5*(AA+SQRT(AA**2+BB**2))/PRC                                     PLAN6350
      IF (R.GT.RMAX) RMAX=R                                                PLAN6360
C*************************************************************************PLAN6370
C-----GENERAL BUCKLING OF PANEL                                            PLAN6380
C*************************************************************************PLAN6390
      IF (PX.LT.0.0) GO TO 118                                             PLAN6400
      PF=GRC*XINERT*AREA*AREA                                              PLAN6410
      AA=PX/PF                                                             PLAN6420
      R=AA**0.2                                                            PLAN6430
      IF (R.GT.RMAX) RMAX=R                                                PLAN6440
  118 AA=RMAX*ADLD(IDVAR)                                                  PLAN6450
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                       PLAN6460
      ANEW(IDVAR)=AA                                                       PLAN6470
      LOAD(IDVAR)=L                                                        PLAN6480
   60 CONTINUE                                                             PLAN6490
      RETURN                                                               PLAN6500
      END                                                                  PLAN6510
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      SUBROUTINE PLNAX2(DWT,ID,X,Y,Z,T,NTC,WT,PMAT,NUMDV,NUMNP,NUMMAT,   PLAN6520
     1 NUMTC,KODE,NUME)                                                  PLAN6530
C*********************************************************************PLAN6540
C-----PLANE ISOTROPIC MEMBRANE ELEMENTS                                  PLAN6550
C*********************************************************************PLAN6560
      IMPLICIT REAL*8 (A-H,O-Z)                                          PLAN6570
      REAL*4 DWT,X,Y,Z,T,WT,PMAT,RFT,F4,F5,F6,FRC                        PLAN6580
      DIMENSION DWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),       PLAN6590
     1T(NUMNP),NTC(NUMMAT),WT(NUMMAT),PMAT(NUMTC,7,NUMMAT)               PLAN6600
      COMMON/FM/LM(12),S(12,12),P(12,4,2),XM(12),ST(15,12),TT(15,4),     PLAN6610
     1 BB(12,12),FM(1891)                                               PLAN6620
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),D(3,3),XX(4),YY(4),ZZ(4),TMP(4),PLAN6630
     1 ALP(3),TTT(3),PRESS,RFET,NS,JUN1,EE(6),JUN(172)                   PLAN6640
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                   PLAN6650
C*********************************************************************PLAN6660
C-----CONTROL INFORMATION                                                PLAN6670
C*********************************************************************PLAN6680
      NU=1                                                               PLAN6690
      ND=12                                                              PLAN6700
      NV=2                                                               PLAN6710
      NW=1                                                               PLAN6720
      NI=4                                                               PLAN6730
      IEX=0                                                              PLAN6740
      WRITE(IW,2000)NUME,KODE,NUMMAT,NUMTC                               PLAN6750
C*********************************************************************PLAN6760
C-----MATERIAL PROPERTY CARDS                                            PLAN6770
C*********************************************************************PLAN6780
      WRITE(IW,2019)                                                     PLAN6790
      DO 60 M=1,NUMMAT                                                   PLAN6800
      READ(IR,1010) N,NTC(N),WT(N)                                       PLAN6810
      IF(NTC(N).LE.0) NTC(N)=1                                           PLAN6820
      WRITE(IW,2020) N,NTC(N),WT(N)                                      PLAN6830
C*********************************************************************PLAN6840
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                          PLAN6850
C*********************************************************************PLAN6860
      NT=NTC(N)                                                          PLAN6870
      READ(IR,1005) ((PMAT(I,J,N),J=1,7),I=1,NT)                         PLAN6880
      DO 10 I=1,NT                                                       PLAN6890
      IF(PMAT(I,6,N).LE.0.) PMAT(I,6,N)=PMAT(I,5,N)                      PLAN6900
   10 CONTINUE                                                           PLAN6910
   60 WRITE(IW,2010) ((PMAT(I,J,N),J=1,7),I=1,NT)                        PLAN6920
C*********************************************************************PLAN6930
C-----ELEMENT LOAD MULTIPLIERS                                           PLAN6940
C*********************************************************************PLAN6950
      READ (IR,1002) ((EMUL(I,J),J=1,5),I=1,4)                           PLAN6960
      WRITE(IW,2004) ((EMUL(I,J),J=1,5),I=1,4)                           PLAN6970
C*********************************************************************PLAN6980
C-----ELEMENT CARDS                                                      PLAN6990
C*********************************************************************PLAN7000
      WRITE (6,2002)                                                     PLAN7010
      N=1                                                                PLAN7020
  130 READ(IR,1003) IEL,IE,IMAT,IDV,FRC,RFET,PRESS,BETA,NS,INC           PLAN7030
      IF (FRC.LE.0.) FRC=1.                                              PLAN7040
      IF(INC.EQ.0) INC=1                                                 PLAN7050
      IF(NS.EQ.0) NS=3                                                   PLAN7060
      IF(NS.LT.3) NS=1                                                   PLAN7070
      IF( IE(3) .EQ. IE(4)) .AND. (NS.EQ. 15) ) NS=12                    PLAN7080
      RHO=WT(IMAT)                                                       PLAN7090
      THICK=1.0                                                          PLAN7100
      RFT=BETA                                                           PLAN7110
```

```
      KK=INC*(IEL-N)                                                    PLAN7120
      DO 142 I=1,4                                                      PLAN7130
  142 IX(I)=IE(I)-KK                                                    PLAN7140
      DO 500 NEL=N,IEL                                                  PLAN7150
      TEMP=0.                                                           PLAN7160
      DO 501 I=1,4                                                      PLAN7170
      II=IX(I)                                                          PLAN7180
      TEMP=TEMP+T(II)*0.25                                              PLAN7190
      XX(I)=X(II)                                                       PLAN7200
      YY(I)=Y(II)                                                       PLAN7210
  501 ZZ(I)=Z(II)                                                       PLAN7220
C*********************************************************************PLAN7230
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE   PLAN7240
C*********************************************************************PLAN7250
      CALL INTERP(PMAT,EE,NUMTC,NUMMAT,7,6,NTC(IMAT),IMAT,TEMP)         PLAN7260
      E4=EE(4)                                                          PLAN7270
      E5=EE(5)                                                          PLAN7280
      E6=EE(6)                                                          PLAN7290
C*********************************************************************PLAN7300
C-----FORM CONSTITUTIVE LAW AND COMPUTE THERMAL STRESSES                PLAN7310
C*********************************************************************PLAN7320
      DO 265 I=1,3                                                      PLAN7330
      DO 265 J=1,3                                                      PLAN7340
  265 D(I,J)=0.                                                         PLAN7350
      D(2,2)=1.0/EE(1)                                                  PLAN7360
      D(1,1)=D(2,2)                                                     PLAN7370
      D(1,2)=-D(1,1)*EE(2)                                              PLAN7380
      D(2,1)=D(1,2)                                                     PLAN7390
      D(3,3)=D(2,2)*2.0*(1.0+EE(2))                                     PLAN7400
      ALP(1)=EE(3)                                                      PLAN7410
      ALP(2)=EE(3)                                                      PLAN7420
      ALP(3)=0.                                                         PLAN7430
      CALL FLAW(0.000)                                                  PLAN7440
C*********************************************************************PLAN7450
C-----FORM ELEMENT LOCATION MATRIX AND COMPUTE ELEMENT MATRICES         PLAN7460
C*********************************************************************PLAN7470
      DO 170 I=1,4                                                      PLAN7480
      II=IX(I)                                                          PLAN7490
      IMP(I)=T(II)                                                      PLAN7500
      LM(I)=ID(II,1)                                                    PLAN7510
      LM(I+4)=ID(II,2)                                                  PLAN7520
  170 LM(I+8)=ID(II,3)                                                  PLAN7530
      CALL QUAD(RHO,THICK)                                              PLAN7540
      AREA=XM(1)+XM(2)+XM(3)+XM(4)                                      PLAN7550
      WT(IDV)=WT(IDV)+AREA*RHO*FRC                                      PLAN7560
C*********************************************************************PLAN7570
C-----CALCULATE BANDWIDTH AND WRITE ELEMENT INFO. ON TAPES              PLAN7580
C*********************************************************************PLAN7590
      NN=NS*ND*NU                                                       PLAN7600
      CALL REARAN (ST,ST,15,12,1,NS,ND,NU,NN)                           PLAN7610
      NN=NS*4*NW                                                        PLAN7620
      CALL REARAN(TT,TT,15,4,1,NS,4,NW,NN)                              PLAN7630
      CALL CALBAN(NDIF,LM,S,P ,ST,TT,NU,NV,NS,ND,NW,IDV,IFX,FRC)        PLAN7640
      WRITE (IR) NI,BET ,E4,E5,E6                                       PLAN7650
      WRITE(IW,2003) NEL,IX,IMAT,IDV,FRC,REF1,PRESS,BETA,NS,NDIF        PLAN7660
      DO 450 I=1,4                                                      PLAN7670
  450 IX(I)=IX(I)+INC                                                   PLAN7680
  500 CONTINUE                                                          PLAN7690
      N=IEL+1                                                           PLAN7700
      IF(N.LE.NUME) GO TO 130                                           PLAN7710
```

```
      RETURN                                                            PLAN7720
 1002 FORMAT(5E10.0)                                                    PLAN7730
 1003 FORMAT(7I5,E5.0,3E10.0,2I5)                                       PLAN7740
 1005 FORMAT (7E10.0)                                                   PLAN7750
 1010 FORMAT(2I5, E10.0)                                                PLAN7760
 2000 FORMAT(44H1NUMBER OF MEMBRANE ELEMENTS                  =,I5  /   PLAN7770
     1       44H CONSTRUCTION KODE                           =,I5/     PLAN7780
     2       44H NUMBER OF MATERIALS                         =,I5/     PLAN7790
     3       44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5)       PLAN7800
 2002 FORMAT(/ /23H PROCESSED ELEMENT DATA//                            PLAN7810
     1 97H ELEMT/-------NODES------//-ID NOS-/   DES VAR    REFERENCE   PLAN7820
     2                          PRNT  BAND  ,/                         PLAN7830
     3 97H NUMBR   I     J     K     L    MAT  DV    FRACTION      TEMP  PLAN7840
     4PRESSURE       BETA        CODE  WIDTH      /)                    PLAN7850
 2003 FORMAT(1X,7I5,4E12.4,2I6)                                         PLAN7860
 2004 FORMAT(23H ELEMENT LOAD FRACTIONS//71H LOAD CASE  TEMPERATURE   PREPLAN7870
     1SSURE   X-DIRECTION Y-DIRECTION Z-DIRECTION /                     PLAN7880
     2 6X ,1HA ,3X ,5E12.3/ 6X ,1HB ,3X ,5E12.3/ 6X ,1HC ,3X ,5E12.3/   PLAN7890
     3 6X ,1HD ,3X ,5E12.3  )                                           PLAN7900
 2010 FORMAT(1H+,27X,7E14.4 /(28X,7E14.4))                              PLAN7910
 2019 FORMAT(// 25H MATERIAL PROPERTY CARDS   /                         PLAN7920
     1/125H  MATL  NO OF   SPECIFIC                    YOUNGS       POIPLAN7930
     2SSONS     COEFFT OF   /----------ALLOWABLE STRESSES----------/   PLAN7940
     3/121H  NBR   TEMP     WEIGHT      TEMPERATURE     MODULUS       RPLAN7950
     4ATIO     THERM EXPN       TENSION     COMPRESSION      SHEAR/)    PLAN7960
 2020 FORMAT(1X,I4,I6,2X,F14.4)                                         PLAN7970
      END                                                               PLAN7980
```

```
      SUBROUTINE DPLAN2 (AOLD,ANEW,LOAD,NUMDV)                          PLAN7990
C*********************************************************************PLAN8000
C-----STRESS DESIGN OF  ISOTROPIC MEMBRANE ELEMENT                      PLAN8010
C*********************************************************************PLAN8020
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                     PLAN8030
      COMMON/JUNK/JUN(16),LT,LH,L,SG(20),SIG(7),IDVAR,IEX,ERC,AREA,     PLAN8040
     1 XINERT,BETA,TENS,COMP,SHEAR,JUN1(245)                            PLAN8050
      CC=(SIG(1)+SIG(2))*0.5                                            PLAN8060
      BB=(SIG(1)-SIG(2))*0.5                                            PLAN8070
      CR=SQRT(BB*BB+SIG(3)**2)                                          PLAN8080
      PX=CC+CR                                                          PLAN8090
      PY=CC-CR                                                          PLAN8100
      P1=COMP*AREA                                                      PLAN8110
      P2=COMP*AREA                                                      PLAN8120
      IF (PX.GT.0.0) P1=TENS    *AREA                                   PLAN8130
      IF (PY.GT.0.0) P2=TENS*AREA                                       PLAN8140
      RMAX=(PX/P1)**2+(PY/P2)**2-(PX/P1)*(PY/P2)                        PLAN8150
      RMAX=SQRT(RMAX)                                                   PLAN8160
      IF(SHEAR.EQ.0.) GO TO 50                                          PLAN8170
      PXY=CR/(AREA*SHEAR)                                               PLAN8180
      IF(RMAX.LT.PXY) RMAX=PXY                                          PLAN8190
   50 AA=RMAX*AOLD(IDVAR)                                               PLAN8200
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                    PLAN8210
      ANEW(IDVAR)=AA                                                    PLAN8220
      LOAD(IDVAR)=L                                                     PLAN8230
   60 RETURN                                                            PLAN8240
      END                                                               PLAN8250
```

```
      SUBROUTINE SHEAR(A,MTOT)                                          SHER0000
C*********************************************************************SHER0010
C-----SHEAR PANEL ELEMENTS                                              SHER0020
C*********************************************************************SHER0030
      DIMENSION A(MTOT)                                                 SHER0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTTT,NEQSHER0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LB,NEQB,NBLOCK                           SHER0060
      COMMON/JUNK/JUN(16),LT,LH,L,SIG(27),IDVAR,TEX,ERC,AREA,XINERT,    SHER0070
     1 JUN1(249)                                                        SHER0080
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                  SHER0090
      NUME=NPAR(2)                                                      SHER0100
      KODE=NPAR(5)                                                      SHER0110
      IF(NPAR(1).EQ.0)GO TO 500                                         SHER0120
      N6=N5+NUMNP                                                       SHER0130
      GO TO (1,2),KODE                                                  SHER0140
C*********************************************************************SHER0150
C-----SHEAR PANEL WITH STRESS AND BUCKLING CONSTRAINTS                  SHER0160
C*********************************************************************SHER0170
    1 NUMMAT=NPAR(3)                                                    SHER0180
      NUMTC=NPAR(4)                                                     SHER0190
      N7=N6+NUMMAT                                                      SHER0200
      N8=N7+NUMMAT                                                      SHER0210
      N9=N8+NUMMAT*NUMTC*4                                              SHER0220
      MM=N9-MTOT                                                        SHER0230
      IF(MM.GT.0)CALL ERROR(MM)                                         SHER0240
      CALL PANEL(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),       SHER0250
     1 A(N8),NUMDV,NUMNP,NUMMAT,NUMTC,KODE,NUME)                        SHER0260
      RETURN                                                            SHER0270
C*********************************************************************SHER0280
C-----PROVISION FOR SPECIAL SHEAR PANEL ELEMENT                         SHER0290
C*********************************************************************SHER0300
    2 CALL NOELEM (NPAR(1),NPAR(5),IW)                                  SHER0310
      RETURN                                                            SHER0320
  500 WRITE (IW,2002)  KODE                                             SHER0330
      DO 800 MM=1,NUME                                                  SHER0340
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,I8,0)                SHER0350
      AA=A(IDVAR)*ERC                                                   SHER0360
      WRITE (IW,2005) MM,AA                                             SHER0370
      DO 800 L=LT,LH                                                    SHER0380
      IF(L.GT.LT ) WRITE(IW,2006)                                       SHER0390
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,I8,1)                SHER0400
      SIG(5) = (SIG(1)+SIG(2)+SIG(3)+SIG(4))  *0.25                     SHER0410
      WRITE (IW,2007) L,(SIG(I),I=1,5)                                  SHER0420
      GO TO (3,4),KODE                                                  SHER0430
C*********************************************************************SHER0440
C-----DESIGN OF SHEAR PANEL WITH STRESS AND BUCKLING CONSTRAINTS        SHER0450
C*********************************************************************SHER0460
    3 CALL DPANEL (A(M1),A(M2),A(M3),NUMDV)                             SHER0470
      GO TO 800                                                         SHER0480
C*********************************************************************SHER0490
C-----PROVISION FOR DESIGN OF SPECIAL SHEAR PANEL ELEMENT               SHER0500
C*********************************************************************SHER0510
    4 CONTINUE                                                          SHER0520
  800 CONTINUE                                                          SHER0530
      RETURN                                                            SHER0540
 2002 FORMAT(//40H ANALYSIS OF SHEAR PANELS, CONSTRN CODE=,I2 //        SHER0550
     1 92H                              LOAD  /--------------SHEAR FLOW AT NOSHER0560
     2DES--------------/   AVERAGE    /                                 SHER0570
     3 92H ELEMENT    THICKNESS      COND                               SHER0580
     4X            L       SHEAR FLOW /)                               SHER0590
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 2005 FORMAT(I6,1X,F15.4)                                                SHER0600
 2006 FORMAT(/)                                                          SHER0610
 2007 FORMAT(1H4,23X,I5,1X,5E12.4)                                       SHER0620
      END                                                                SHER0630



      SUBROUTINE PANEL(IWT,ID,X,Y,Z,T,NTC,WT ,PMAT,NUMDV,NUMNP,NUMMAT,  SHER0640
     1 NUMTC,KODE,NUME)                                                  SHER0650
C*************************************************************************SHER0660
C-----SHEAR PANEL ELEMENTS                                               SHER0670
C*************************************************************************SHER0680
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHER0690
      REAL*4 IWT,X,Y,Z,T,WT,PMAT,ERC,E3,SHCR                             SHER0700
      DIMENSION IWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),       SHER0710
     1T(NUMNP),NTC(NUMMAT),WT (NUMMAT),PMAT(NUMTC,4,NUMMAT),CC(6,2)      SHER0720
      COMMON/EM/LM(12),S(12,12),P(12,4),ST(4,12),TT(4,4),XM(12),         SHER0730
     1 EM1(2259)                                                         SHER0740
      COMMON/JUNK/EMUL(3,4),IE(4),IX(4),XX(4),YY(4),ZZ(4),EE(3),AREA,    SHER0750
     1       TE(4,2),U(4),V(4),O(4),D(4),P1,P2 ,JUN1(184)                SHER0760
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                   SHER0770
      DATA CC/5.35 , 8.99 , 8.99 , 5.35 , 5.35 , 7.07 ,                  SHER0780
     1        3.99 , 5.72 , 3.29 , 7.25 , 5.63 , 3.91 /                  SHER0790
C*************************************************************************SHER0800
C-----CONTROL INFORMATION                                                SHER0810
C*************************************************************************SHER0820
      MI=1                                                               SHER0830
      MV=1                                                               SHER0840
      MW=1                                                               SHER0850
      MD=12                                                              SHER0860
      MS=4                                                               SHER0870
      IEX=3                                                              SHER0880
      MJ=2                                                               SHER0890
      WRITE(IW,2000)NUME,KODE,NUMMAT,NUMTC                               SHER0900
C*************************************************************************SHER0910
C-----MATERIAL PROPERTY CARDS                                            SHER0920
C*************************************************************************SHER0930
      WRITE(IW,2001)                                                     SHER0940
      DO 5  M=1,NUMMAT                                                   SHER0950
      READ(IR,1001) N,NTC(N),WT(N)                                       SHER0960
      IF (NTC(N).EQ.0) NTC(N)=1                                          SHER0970
      WRITE(IW,2002) N,NTC(N),WT(N)                                      SHER0980
C*************************************************************************SHER0990
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                           SHER1000
C*************************************************************************SHER1010
      NT=NTC(N)                                                          SHER1020
      DO 5 J=1,NT                                                        SHER1030
      READ (IR,5001) (PMAT(J,K,N),K=1,4)                                 SHER1040
      IF (J.NE.1) WRITE (IW,6002)                                        SHER1050
    5 WRITE (IW,6003) (PMAT(J,K,N),K=1,4)                                SHER1060
C*************************************************************************SHER1070
C-----ELEMENT LOAD MULTIPLIERS                                           SHER1080
C*************************************************************************SHER1090
      READ (IR,1003) ((EMUL(I,J),J=1,4),I=1,3)                           SHER1100
      WRITE(IW,2003) ((EMUL(I,J),J=1,4),I=1,3)                           SHER1110
C*************************************************************************SHER1120
C-----ELEMENT CARDS                                                      SHER1130
C*************************************************************************SHER1140
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      WRITE(IW,2005)                                                    SHER1150
      N=1                                                               SHER1160
    6 READ(IR,1004) IEL,IE,IMAT,IDV,ISU,FRC,AL,BL,INC                   SHER1170
      IF(INC.EQ.0) INC=1                                                SHER1180
      IF(FRC.LE.0.0) FRC=1.0                                            SHER1190
      IF(IMAT.EQ.0) IMAT=1                                              SHER1200
      RHO=WT(IMAT)                                                      SHER1210
      KK=INC*(IEL-N)                                                    SHER1220
      DO 50 I=1,4                                                       SHER1230
   50 IX(I)=IE(I)-KK                                                    SHER1240
      DO 500 NEL=N,IEL                                                  SHER1250
      TEMP=0.                                                           SHER1260
      DO 100 I=1,4                                                      SHER1270
      II=IX(I)                                                          SHER1280
      XX(I)=X(II)                                                       SHER1290
      YY(I)=Y(II)                                                       SHER1300
      ZZ(I)=Z(II)                                                       SHER1310
  100 TEMP=TEMP+T(II)*0.25                                              SHER1320
C*********************************************************************SHER1330
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE   SHER1340
C*********************************************************************SHER1350
      CALL INTERP(PMAT,FF,NUMTC,NUMMAT,4,3,NTC(IMAT),IMAT,TEMP)         SHER1360
      E3=FF(3)                                                          SHER1370
C*********************************************************************SHER1380
C-----FORM ELEMENT UNIT MATRICES AND LOAD VECTORS                       SHER1390
C*********************************************************************SHER1400
      SMOD=0.5*FF(1)/(1.0+FF(2))                                        SHER1410
      CALL FPANEL(SMOD,FF(2),RHO,XL,YL,NEL,IW)                          SHER1420
C*********************************************************************SHER1430
C-----COMPUTE BUCKLING DATA                                             SHER1440
C*********************************************************************SHER1450
      SHCR=0.                                                           SHER1460
      IF(ISU.EQ.0) GO TO 121                                            SHER1470
      IF(XL.GE.YL) GO TO 120                                            SHER1480
      H=YL                                                              SHER1490
      YL=XL                                                             SHER1500
      XL=H                                                              SHER1510
  120 IF(AL.LE.0.) AL=XL                                                SHER1520
      IF(BL.LE.0.) BL=YL                                                SHER1530
      H=CC(ISU,1)+CC(ISU,2)*BL*BL/(AL*AL)                               SHER1540
      SHCR=H*9.8696*FF(1)/(12.0*BL*BL*(1.0-FF(2)*FF(2)))                SHER1550
  121 UWT(IDV)=UWT(IDV)+RHO*AREA*FRC                                    SHER1560
C*********************************************************************SHER1570
C-----FORM LOCATION MATRIX AND COMPUTE BAND WIDTH                       SHER1580
C*********************************************************************SHER1590
      DO 470 I=1,4                                                      SHER1600
      II=IX(I)                                                          SHER1610
      DO 470 J=1,3                                                      SHER1620
      IJ=(I-1)*3+J                                                      SHER1630
  470 LM(IJ)=ID(II,J)                                                   SHER1640
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,FRC)         SHER1650
      WRITE(IR) NI,E3,SHCR                                              SHER1660
      WRITE(IW,2004) NEL,IX,IMAT,IDV,ISU,FRC,AL,BL,NDIF                 SHER1670
C*********************************************************************SHER1680
C-----CHECK FOR MORE ELEMENTS                                           SHER1690
C*********************************************************************SHER1700
      DO 450 I=1,4                                                      SHER1710
  450 IX(I)=IX(I)+INC                                                   SHER1720
  500 CONTINUE                                                          SHER1730
      N=IEL+1                                                           SHER1740
```

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      IF(N.LE.NUME) GO TO 6                                                 SHER1750
      RETURN                                                                SHER1760
 1001 FORMAT(2I5,F10.0)                                                     SHER1770
 1003 FORMAT(4E10.0)                                                        SHER1780
 1004 FORMAT(8I5,3E10.0,I5)                                                 SHER1790
 2000 FORMAT(44H1NUMBER OF SHEAR PANEL ELEMENTS              =,I5/          SHER1800
     1        44H CONSTRUCTION CODE                          =,I5/          SHER1810
     2        44H NUMBER OF MATERIALS                        =,I5/          SHER1820
     4        44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5)           SHER1830
 2001 FORMAT(// 25H MATERIAL PROPERTY CARDS //                              SHER1840
     191H MATERIAL   NUMBER     SPECIFIC                    YOUNGS     POISSNSHER1850
     2        ALLOWABLE            /                                       SHER1860
     391H  NUMBER   OF TEMPS     WEIGHT        TEMP       MODULUS    RATIO  SHER1870
     4          SHEAR               /)                                      SHER1880
 2002 FORMAT(I6,5X,I5,F12.4)                                                SHER1890
 2003 FORMAT(// 25H ELEMENT LOAD MULTIPLIERS //20X,1HA,14X,1HB,14X,1HC,     SHER1900
     1 14X,1HD,/6H X-DIR,4F15.6/ 6H Y-DIR,4F15.6/ 6H Z-DIR,4F15.6 )         SHER1910
 2004 FORMAT(I7,2X,4I6,3I7,3E12.4,I6)                                       SHER1920
 2005 FORMAT(// 23H PROCESSED ELEMENT DATA//                                SHER1930
     196H ELEMENT  /-------NODE NOS------//--EL ID NOS-/  BOUND     DES VSHER1940
     2AR /--EFFECT PANEL DIMNS--/  BAND   /                                 SHER1950
     396H  NUMBER       I      J      K      L   MATL  D VAR   CODE   FRACTISHER1960
     40N      LONGER      SHORTER   WIDTH   /)                             SHER1970
 5001 FORMAT(4E10.0)                                                        SHER1980
 6002 FORMAT(/)                                                             SHER1990
 6003 FORMAT(1H+,30X,4E12.4)                                                SHER2000
      END                                                                   SHER2010
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      SUBROUTINE EPANEL(G,GG,RHO,XL,YL,MK,IW)                          SHER2020
C*****************************************************************SHER2030
C-----FORM SHEAR PANEL ELEMENT MATRICES                              SHER2040
C*****************************************************************SHER2050
      IMPLICIT REAL*8 (A-H,O-Z)                                        SHER2060
      COMMON/JUNK/EMUL(3,4),TE(4),IX(4),X (4),Y (4),Z (4),EE(3),AREA,  SHER2070
     1       TE(4,2),U(4),V(4),Q(4),D(4),P1,P2,VD1(4),VD2(4),V12(4),   SHER2080
     2 V41(4),VP12(4),TI(3),TJ(3) ,JUN(132)                           SHER2090
      COMMON/EM/LM(12),S (12,12),P (12,4),ST(4,12),TT(4,4),XM(12),     SHER2100
     1 EMM(2259)                                                      SHER2110
C*****************************************************************SHER2120
C-----UNIT VECTORS ALONG DIAGONALS ,SIDES AND NORMAL TO THE MEANPLANE  SHER2130
C*****************************************************************SHER2140
      CALL VECTOR (VD1,X(1),Y(1),Z(1),X(3),Y(3),Z(3))                  SHER2150
      CALL VECTOR (VD2,X(2),Y(2),Z(2),X(4),Y(4),Z(4))                  SHER2160
      CALL VECTOR (V12,X(1),Y(1),Z(1),X(2),Y(2),Z(2))                  SHER2170
      CALL VECTOR (V41,X(4),Y(4),Z(4),X(1),Y(1),Z(1))                  SHER2180
      CALL CROSS (VD1,VD2,D)                                           SHER2190
      AREA=0.5*VD1(4)*VD2(4)*D(4)                                      SHER2200
C*****************************************************************SHER2210
C-----FORM TRANSFORMATION MATRIX TE                                  SHER2220
C*****************************************************************SHER2230
      HH=DOT(V12,D)                                                    SHER2240
      DO 10 I=1,3                                                      SHER2250
   10 VP12(I)=(V12(I)-HH*D(I))*V12(4)                                  SHER2260
      VP12(4)=DSQRT(VP12(1)*VP12(1)+VP12(2)*VP12(2)+VP12(3)*VP12(3))   SHER2270
      DO 20 I=1,3                                                      SHER2280
   20 TE(I,1)=VP12(I)/VP12(4)                                          SHER2290
      CALL CROSS(D,TE,TE(1,2))                                         SHER2300
C*****************************************************************SHER2310
C-----COMPUTE ELEMENT CORNER COORDINATES IN LOCAL AXES SYSTEM         SHER2320
C*****************************************************************SHER2330
      X1=0.0                                                           SHER2340
      Y1=0.0                                                           SHER2350
      X2=VP12(4)                                                       SHER2360
      Y2=0.0                                                           SHER2370
      X3=DOT(TE,VD1)*VD1(4)                                            SHER2380
      Y3=DOT(TE(1,2),VD1)*VD1(4)                                       SHER2390
      X4=-DOT(TE,V41)*V41(4)                                           SHER2400
      Y4=-DOT(TE(1,2),V41)*V41(4)                                      SHER2410
      XL=0.5*(X2-X1+X3-X4)                                             SHER2420
      YL=0.5*(Y3+Y4)                                                   SHER2430
      X34=X3-Y3*X4/Y4                                                  SHER2440
      X42=X4-X2+(X2-X3)*Y4/Y3                                          SHER2450
      IF(Y3.LT..01.OR.Y4.LT..01.OR.X34.LT..01.OR.X42.GT..01) GO TO 2006 SHER2460
      GO TO 57                                                         SHER2470
 2006 WRITE (IW,2007) MK                                               SHER2480
      STOP                                                             SHER2490
C*****************************************************************SHER2500
C-----TEST FOR PARALLEL SIDES                                        SHER2510
C*****************************************************************SHER2520
   57 A1=DABS((Y3-Y4)/(X3-X4))                                         SHER2530
      A2=DABS(Y4*(X3-X2)-Y3*X4)/(X4*(X3-X2)+Y4*Y3)                     SHER2540
      IF(A1.LE..01.AND.A2.LE..01) GO TO 40                             SHER2550
      IF(A1.LE..01) GO TO 30                                           SHER2560
      IF(A2.LE..01) GO TO 35                                           SHER2570
      GO TO 45                                                         SHER2580
C*****************************************************************SHER2590
C-----CASE WHEN SIDES 1 AND 3 ARE PARALLEL                           SHER2600
C*****************************************************************SHER2610
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```
   30 YP=X2*Y3*Y4/(Y3*X4-Y4*(X3-X2))                                    SHER2620
      P1=YP-Y1                                                          SHER2630
      P2=YP-Y2                                                          SHER2640
      P3=YP-Y3                                                          SHER2650
      P4=YP-Y4                                                          SHER2660
      XP=X2*Y3*X4/(Y3*X4-Y4*(X3-X2))                                    SHER2670
      AA=(X2-XP)/YP                                                     SHER2680
      CC=(X1-XP)/YP                                                     SHER2690
      H=P1*P2*AREA/(P3*P4*2.0*G)                                        SHER2700
      H=H+H*(AA*AA+AA*CC+CC*CC)/(1.5*(1.0+GG))                          SHER2710
      GO TO 46                                                          SHER2720
C*********************************************************************SHER2730
C-----CASE WHEN SIDES 2 AND 4 ARE PARALLEL                             SHER2740
C*********************************************************************SHER2750
   35 DD=-0.5*(X4/Y4+(X3-X2)/Y3)                                        SHER2760
      X0=X4-(X3-X4)*Y4/(Y3-Y4)                                          SHER2770
      AD=1.0/DSQRT(1.0+DD*DD)                                           SHER2780
      P1=(X0-X1-Y1*DD)*AD                                               SHER2790
      P2=(X0-X2-Y2*DD)*AD                                               SHER2800
      P3=(X0-X3-Y3*DD)*AD                                               SHER2810
      P4=(X0-X4-Y4*DD)*AD                                               SHER2820
      BB=((X0-X4)*DD+Y4)/(X0-X4-Y4*DD)                                  SHER2830
      H=P1*P2*AREA/(P3*P4*2.0*G)                                        SHER2840
      H=H+H*(BB*BB+BB*DD+DD*DD)/(1.5*(1.0+GG))                          SHER2850
      GO TO 46                                                          SHER2860
C*********************************************************************SHER2870
C-----PARALLELOGRAM CASE                                               SHER2880
C*********************************************************************SHER2890
   40 P1=1.0                                                            SHER2900
      P2=1.0                                                            SHER2910
      P3=1.0                                                            SHER2920
      P4=1.0                                                            SHER2930
      DD=-0.5*(X4/Y4+(X3-X2)/Y3+(Y3-Y4)/(X3-X4))                        SHER2940
      H=0.5*AREA*(1.0+2.0*DD*DD/(1.0+GG))/G                             SHER2950
      GO TO 46                                                          SHER2960
C*********************************************************************SHER2970
C-----CASE WHEN NO PARALLEL SIDES ARE PRESENT                          SHER2980
C*********************************************************************SHER2990
   45 X0=X4-(X3-X4)*Y4/(Y3-Y4)                                          SHER3000
      XP=X2*X4*Y3/(Y3*X4-Y4*(X3-X2))                                    SHER3010
      YP=X2*Y3*Y4/(Y3*X4-Y4*(X3-X2))                                    SHER3020
      DIS=DSQRT((X0-XP)*(X0-XP)+YP*YP)                                  SHER3030
      DD=(X0-XP)/YP                                                     SHER3040
      P1=YP*(X0-X1-Y1*DD)/DIS                                           SHER3050
      P2=YP*(X0-X2-Y2*DD)/DIS                                           SHER3060
      P3=YP*(X0-X3-Y3*DD)/DIS                                           SHER3070
      P4=YP*(X0-X4-Y4*DD)/DIS                                           SHER3080
      CC=DIS/P1-DD                                                      SHER3090
      BB=DIS/P4-CC                                                      SHER3100
      AA=DIS/P2-DD                                                      SHER3110
      F=(AA+BB+(AA**3+BB**3)/1.5+0.2*(AA**5+BB**5))*DLOG(DABS(AA+BB))   SHER3120
     1 +(CC+DD+(CC**3+DD**3)/1.5+0.2*(CC**5+DD**5))*DLOG(DABS(CC+DD))   SHER3130
     2-(BB+CC+(BB**3+CC**3)/1.5+0.2*(BB**5+CC**5))*DLOG(DABS(BB+CC))    SHER3140
     3-(DD+AA+(DD**3+AA**3)/1.5+0.2*(DD**5+AA**5))*DLOG(DABS(DD+AA))    SHER3150
     4+0.1*(-(AA*AA-CC*CC)*(BB**3-DD**3)+(BB*BB-DD*DD)*(AA**3-CC**3))   SHER3160
     5-0.2*((AA-CC)*(BB**4-DD**4)+(BB-DD)*(AA**4-CC**4))                SHER3170
      F=F*P1*P2*P3*P4*0.5/(DIS*DIS)                                     SHER3180
      H=0.5*P1*P2*(AREA+4.0*(F-AREA/1.5)/(1.0+GG))/(P3*P4*G)            SHER3190
C*********************************************************************SHER3200
C-----DEVELOP UNIT STIFFNESS MATRIX                                    SHER3210
```

```
C*************************************************************************SHER3220
   46 DF13=DSQRT(X3*X3+Y3*Y3)                                               SHER3230
      DF24=DSQRT((X4-X2)*(X4-X2)+Y4*Y4)                                     SHER3240
      U(1)=X3/DF13                                                          SHER3250
      U(2)=(X4-X2)/DF24                                                     SHER3260
      V(1)=Y3/DF13                                                          SHER3270
      V(2)=Y4/DF24                                                          SHER3280
      DO 47 I=3,4                                                           SHER3290
      U(I)=U(I-2)                                                           SHER3300
   47 V(I)=V(I-2)                                                           SHER3310
      Q(1)=-X2*Y4*DF13*0.5/(X4*Y3-X3*Y4)                                    SHER3320
      Q(2)=X2*Y3*DF24*0.5/(X4*Y3-X3*Y4-X2*(Y3-Y4))                          SHER3330
      Q(3)=-Q(1)                                                            SHER3340
      Q(4)=-Q(2)                                                            SHER3350
      DO 100 I=1,4                                                          SHER3360
      DO 100 J=1,I                                                          SHER3370
      QIJ= Q(I)*Q(J)*0.5/H                                                  SHER3380
      DO 150 L=1,3                                                          SHER3390
      TI(L)=TF(L,1)*U(I)+TF(L,2)*V(I)                                       SHER3400
  150 TJ(L)=U(J)*TF(L,1)+V(J)*TF(L,2)                                       SHER3410
      DO 160 L=1,3                                                          SHER3420
      DO 160 NN=1,3                                                         SHER3430
      II=3*(I-1)+L                                                          SHER3440
      JJ=3*(J-1)+NN                                                         SHER3450
  160 S(II,JJ  )=TI(L)*TJ(NN)*QIJ                                           SHER3460
  100 CONTINUE                                                              SHER3470
      DO 180 L=1,12                                                         SHER3480
      DO 180 M=L,12                                                         SHER3490
  180 S(L,M)=S(M,L)                                                         SHER3500
C*************************************************************************SHER3510
C-----DEVELOP UNIT FORCE (STRESS) RECOVERY MATRIX                           SHER3520
C*************************************************************************SHER3530
      DO 300 I=1,4                                                          SHER3540
      II=(I-1)*3                                                            SHER3550
      SN=-Q(I)*0.5/H                                                        SHER3560
      ST(1,II+1  )=SN*(U(I)*TF(1,1)+V(I)*TF(1,2))                           SHER3570
      ST(1,II+2  )=SN*(U(I)*TF(2,1)+V(I)*TF(2,2))                           SHER3580
  300 ST(1,II+3  )=SN*(U(I)*TF(3,1)+V(I)* TF(3,2))                          SHER3590
      DO 400 J=1,12                                                         SHER3600
      STJ=ST(1,J)                                                           SHER3610
      ST(2,J)=STJ*P1/P2                                                     SHER3620
      ST(3,J)=STJ*P1*P2/(P3*P3)                                             SHER3630
      ST(4,J)=STJ*P1*P2/(P4*P4)                                             SHER3640
  400 ST(1,J)=STJ*P2/P1                                                     SHER3650
C*************************************************************************SHER3660
C-----GRAVITY AND INERTIA LOADS                                             SHER3670
C*************************************************************************SHER3680
      A1=0.5*X2*Y4                                                          SHER3690
      A2=0.5*X2*Y3                                                          SHER3700
      A3=AREA-A1                                                            SHER3710
      A4=AREA-A2                                                            SHER3720
      WTT=RHO/3.0                                                           SHER3730
      F1=(A4+A1+A2)*WTT                                                     SHER3740
      F2=(A1+A2+A3)*WTT                                                     SHER3750
      F3=(A2+A3+A4)*WTT                                                     SHER3760
      F4=(A3+A4+A1)*WTT                                                     SHER3770
      DO 450 I=1,3                                                          SHER3780
      XM(I)=F1                                                              SHER3790
      XM(I+3)=F2                                                            SHER3800
      XM(I+6)=F3                                                            SHER3810
```

```
      XM(I+9)=F4                                                        SHER3820
      DO 450 L=1,4                                                      SHER3830
      HH=EMUL(I,L)                                                      SHER3840
      P(I  ,L)=HH*F1                                                    SHER3850
      P(I+3,L)=HH*F2                                                    SHER3860
      P(I+6,L)=HH*F3                                                    SHER3870
  450 P(I+9,L)=HH*F4                                                    SHER3880
      DO 460 I=1,4                                                      SHER3890
      DO 460 J=1,4                                                      SHER3900
  460 TT(I,J)=0.0                                                       SHER3910
      RETURN                                                            SHER3920
 2007 FORMAT(1X,'ONE OF THE INTERIOR ANGLES FOR SHEAR PANEL NO.=', I5,' SHER3930
     1 IS GREATER THAN 180 DEGREES.')                                   SHER3940
      END                                                               SHER3950
```

```
      SUBROUTINE DPANEL(ADLD,ANEW,LOAD,NUMDV)                           SHER3960
C*********************************************************************SHER3970
C-----DESIGN OF SHEAR PANEL ELEMENTS                                    SHER3980
C*********************************************************************SHER3990
      DIMENSION ADLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                     SHER4000
      COMMON/JUNK/JUN(16),LT,LH,L,SG(27),IDVAR,IFX,FRC,AREA,XINERT,     SHER4010
     1 SHEAR,SHCR,JUN1(247)                                             SHER4020
C*********************************************************************SHER4030
C-----CHECK SHEAR STRESS                                                SHER4040
C*********************************************************************SHER4050
      SHELW=ABS(SG(5))                                                  SHER4060
      RMAX=SHELW/(SHEAR*AREA)                                           SHER4070
C*********************************************************************SHER4080
C-----CHECK BUCKLING                                                    SHER4090
C*********************************************************************SHER4100
      IF (SHCR.LE.0.0) GO TO 4                                          SHER4110
      R=SHELW/(SHCR*XINERT)                                             SHER4120
      R=R**0.333333                                                     SHER4130
    3 IF (RMAX.LT.R) RMAX=R                                             SHER4140
C*********************************************************************SHER4150
C-----FULLY STRESSED DESIGN                                             SHER4160
C*********************************************************************SHER4170
    4 AA=RMAX*ADLD(IDVAR)                                               SHER4180
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                    SHER4190
      ANEW(IDVAR)=AA                                                    SHER4200
      LOAD(IDVAR)=L                                                     SHER4210
   60 CONTINUE                                                          SHER4220
      RETURN                                                            SHER4230
      END                                                               SHER4240
```

```
      SUBROUTINE SHELL (A,MTOT)                                          SHEL0000
C*********************************************************************SHEL0010
C-----PLATE/SHELL ELEMENTS                                               SHEL0020
C*********************************************************************SHEL0030
      DIMENSION A(MTOT)                                                  SHEL0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,NEQSHEL0050
     . ,NUMEL,NUMDV,M1,M2,M3,LL,LR,NEQB,NBLOCK                           SHEL0060
      COMMON/JUNK/JUN(16),LT,LH,L,SG(20) ,SIG(7),IDV,IEX,ERC,THICK,      SHEL0070
     1 X(NERT,TEN,COMP,SHEAR,BETA,JUN)(245)                              SHEL0080
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                   SHEL0090
      NUME= NPAR(2)                                                      SHEL0100
      KODE=NPAR(5)                                                       SHEL0110
      IF(NPAR(1).EQ.0) GO TO 500                                         SHEL0120
      NUMMAT=NPAR(3)                                                     SHEL0130
      NUMTC=NPAR(4)                                                      SHEL0140
      N6=N5+NUMNP                                                        SHEL0150
      N7=N6+NUMMAT                                                       SHEL0160
      N8=N7+NUMMAT                                                       SHEL0170
      GO TO (1,2),KODE                                                   SHEL0180
C*********************************************************************SHEL0190
C-----ISOTROPIC PLATE/SHELL ELEMENTS                                     SHEL0200
C*********************************************************************SHEL0210
    1 N9=N8+NUMMAT*NUMTC*7                                               SHEL0220
      MM=N9-MTOT                                                         SHEL0230
      IF(MM.GT.0) CALL ERROR(MM)                                         SHEL0240
      CALL PLATE1(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),SHEL0250
     1 NUMDV,NUMNP,NUME,NUMMAT,NUMTC,KODE)                               SHEL0260
      RETURN                                                             SHEL0270
C*********************************************************************SHEL0280
C-----ORTHOTROPIC PLATE/SHELL ELEMENTS                                   SHEL0290
C*********************************************************************SHEL0300
    2 CALL NOELEM(NPAR(1),KODE,IW)                                       SHEL0310
      RETURN                                                             SHEL0320
  500 WRITE(IW,2002) KODE                                                SHEL0330
      DO 800  MM=1,NUME                                                  SHEL0340
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,I8,0)                 SHEL0350
      WRITE(IW,2001) MM,THICK                                            SHEL0360
      TETA=BETA/57.2957795                                               SHEL0370
      CB=COS(TETA)                                                       SHEL0380
      SB=SIN(TETA)                                                       SHEL0390
      CSB=CB*SB                                                          SHEL0400
      CB=CB*CB                                                           SHEL0410
      SB=SB*SB                                                           SHEL0420
      DO 800 L=LT,LH                                                     SHEL0430
      IF(L.GT.LT) WRITE(IW,2004)                                         SHEL0440
      CALL STRSC (A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,I8,1)                SHEL0450
      IF(BETA.NE.0.) GO TO 20                                            SHEL0460
      DO 30 I=1,6                                                        SHEL0470
   30 SIG(I)=SG(I)                                                       SHEL0480
      GO TO 40                                                           SHEL0490
   20 DO 10 I=1,4,3                                                      SHEL0500
      C1=SG(I)*CB+SG(I+1)*SB                                             SHEL0510
      C2=2.0*SG(I+2)*CSB                                                 SHEL0520
      SIG(I)= C1+C2                                                      SHEL0530
      SIG(I+1)=C1-C2                                                     SHEL0540
   10 SIG(I+2)=(-SG(I)+SG(I+1))*CSB+SG(I+2)*(CB-SB)                      SHEL0550
   40 WRITE(IW,2003) L,(SIG(I),I=1,6)                                    SHEL0560
      GO TO (3,4),KODE                                                   SHEL0570
C*********************************************************************SHEL0580
C-----DESIGN OF ISOTROPIC PLATE/SHELL ELEMENTS                           SHEL0590
```

```
C*******************************************************************************SHEL0600
      3 CALL DSHELI(A(M1),A(M2),A(M3),NUMDV    )                                 SHEL0610
        GO TO 800                                                                SHEL0620
C*******************************************************************************SHEL0630
C-----DESIGN OF ORTHOTROPIC SHELL ELEMENTS                                       SHEL0640
C*******************************************************************************SHEL0650
      4 CONTINUE                                                                 SHEL0660
    800 CONTINUE                                                                 SHEL0670
        RETURN                                                                   SHEL0680
C*******************************************************************************SHEL0690
 2001 FORMAT(1X,I7,F14.4)                                                        SHEL0700
 2002 FORMAT(//49H ANALYSIS OF PLATE/SHELL ELEMENTS ,CONSTRN CODE =,I9//SHEL0710
     1          113H ELEMENT    ELEMENT      LOAD /-------------MEMBRANE FOSHEL0720
     2RCES------------//--------BENDING/TWISTING MOMENTS--------/  /     SHEL0730
     3         113H  NUMBER    THICKNESS     COND        NXX            NYY   SHEL0740
     4          NXY             MXX           MYY             MXY      / )   SHEL0750
 2003 FORMAT(1H+,20X,I7,6F14.4)                                                  SHEL0760
 2004 FORMAT(/)                                                                  SHEL0770
      END                                                                        SHEL0780
```

```
      SUBROUTINE PLATE1(UWT,ID,X,Y,Z,T,WT,NTC,PMAT,NUMDV,NUMNP,NUME,     SHEL0790
     1 NUMMAT,NUMTC,KODE)                                                SHEL0800
C*********************************************************************SHEL0810
C-----ISOTROPIC PLATE/SHELL ELEMENTS - C.A.FELIPPA'S SHELL ELEMENT      SHEL0820
C-----NOTE (1) PROGRAM INCLUDES TEMP. GRADIENT LOAD VECTORS AND STRESSESSHEL0830
C-----     (2) PROGRAM IS WRITTEN FOR GENERAL ORTHOTROPIC MAT. PROPERTIESHEL0840
C-----THESE ARE NOT USED IN THE PRESENT PROGRAM                         SHEL0850
C*********************************************************************SHEL0860
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHEL0870
      REAL*4 UWT,X,Y,Z,T,WT,PMAT,ERC,E4,E5,E6,BET                        SHEL0880
      DIMENSION UWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),      SHEL0890
     1 T(NUMNP),WT(NUMMAT),NTC(NUMMAT),PMAT(NUMTC,7,NUMMAT)             SHEL0900
      COMMON/JUNK/                                                       SHEL0910
     1 R1(30),R2(30),ST1(6),ST2(6),TO(3,3),XX(5),YY(5),ZZ(5),           SHEL0920
     2 CM(3,3),ALFA(3),RHO ,NEN,NTRI,JX(4),IE(4),PRESS,REET,TEMP,       SHEL0930
     3 DTEMP,EMUL(5,4),EE(12)                                           SHEL0940
      COMMON/EM/ELM(24),S(30,30,2),P(24,4,3),XM(24),ST(6,30,2),TT(6,4,2),SHEL0950
     1 EM1                                                               SHEL0960
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                   SHEL0970
C*********************************************************************SHEL0980
C-----CONTROL INFORMATION                                               SHEL0990
C*********************************************************************SHEL1000
      NU=2                                                               SHEL1010
      NV=2                                                               SHEL1020
      NW=1                                                               SHEL1030
      NS=6                                                               SHEL1040
      NJ=4                                                               SHEL1050
      IEX=3                                                              SHEL1060
      DTEMP =0.                                                          SHEL1070
      WRITE(IW,2000) NUME ,NUMMAT,NUMTC,KODE                             SHEL1080
C*********************************************************************SHEL1090
C-----READ AND PRINT OF MATERIAL PROPERTIES                             SHEL1100
C*********************************************************************SHEL1110
      WRITE(IW,2001)                                                     SHEL1120
      DO 10 N=1,NUMMAT                                                   SHEL1130
      READ(IR,1000) N,NTC(N),WT(N)                                       SHEL1140
      IF(NTC(N).EQ.0) NTC(N)=1                                           SHEL1150
      WRITE(IW,2002) N,NTC(N),WT(N)                                      SHEL1160
      NT=NTC(N)                                                          SHEL1170
      DO 11 I=1,NT                                                       SHEL1180
      READ(IR,1003) (PMAT(I,J,N),J=1,7)                                  SHEL1190
      IF(PMAT(I,6,N).LE.0.) PMAT(I,6,N)=PMAT(I,5,N)                      SHEL1200
      IF(PMAT(I,7,N).LE.0.) PMAT(I,7,N)=PMAT(I,5,N)*0.577                SHEL1210
   11 CONTINUE                                                           SHEL1220
      WRITE(IW,2009) (PMAT(1,J,N),J=1,7)                                 SHEL1230
      IF(NT.GT.1) WRITE(IW,2008) ((PMAT(I,J,N),J=1,7),I=2,NT)            SHEL1240
   10 CONTINUE                                                           SHEL1250
C*********************************************************************SHEL1260
C-----READ AND PRINT OF ELEMENT LOAD MULTIPLIERS                        SHEL1270
C*********************************************************************SHEL1280
      WRITE(IW,2006)                                                     SHEL1290
      READ(IR,1002) ((EMUL(I,J),J=1,4),I=1,5)                            SHEL1300
      WRITE(IW,2007)((J,(EMUL(I,J),I=1,5),J=1,4)                         SHEL1310
C*********************************************************************SHEL1320
C-----READ AND PRINT OF ELEMENT DATA                                    SHEL1330
C*********************************************************************SHEL1340
      WRITE(IW,2003)                                                     SHEL1350
      N=1                                                                SHEL1360
  100 READ(IR,1001) IEL,IF,IMAT,INC,IDV,PRESS,REET,ERC,BETA              SHEL1370
      IF(IEL.LT.N) GO TO 600                                             SHEL1380
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      IF(INC.EQ.0) INC=1                                                SHEL1390
      IF(ERC.EQ.0.) ERC=1.                                              SHEL1400
      IF(IMAT.EQ.0) IMAT=1                                              SHEL1410
      NEN=4                                                             SHEL1420
      ND=24                                                             SHEL1430
      NTRI=4                                                            SHEL1440
      IF(IE(4).NE.0) GO TO 46                                           SHEL1450
      NEN=3                                                             SHEL1460
      ND=18                                                             SHEL1470
      NTRI=1                                                            SHEL1480
      IX(4)=0                                                           SHEL1490
   46 RHO=WT(IMAT)                                                      SHEL1500
      BET=BETA                                                          SHEL1510
      KK=INC*(IEL-N)                                                    SHEL1520
      DO 45 I=1,NEN                                                     SHEL1530
   45 IX(I)=IE(I)-KK                                                    SHEL1540
      DO 500 NEL=N,IEL                                                  SHEL1550
      TEMP=0.                                                           SHEL1560
      DO 40 I=1,NEN                                                     SHEL1570
      J=IX(I)                                                           SHEL1580
      TEMP=TEMP+T(J)                                                    SHEL1590
      XX(I)=X(J)                                                        SHEL1600
      YY(I)=Y(J)                                                        SHEL1610
   40 ZZ(I)=Z(J)                                                        SHEL1620
      TEMP=TEMP/NEN                                                     SHEL1630
      IF(NEN.NE.4) GO TO 75                                             SHEL1640
      XX(5)=0.25*(XX(1)+XX(2)+XX(3)+XX(4))                              SHEL1650
      YY(5)=0.25*(YY(1)+YY(2)+YY(3)+YY(4))                              SHEL1660
      ZZ(5)=0.25*(ZZ(1)+ZZ(2)+ZZ(3)+ZZ(4))                              SHEL1670
C*******************************************************************************SHEL1680
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE    SHEL1690
C*******************************************************************************SHEL1700
   75 CALL INTERP (PMAT,EE,NUMTC,NUMMAT,7,6,NTC(IMAT),IMAT,TEMP)        SHEL1710
      TEMP=TEMP-REFT                                                    SHEL1720
      ALFA(1)=EE(3)                                                     SHEL1730
      ALFA(2)=EE(3)                                                     SHEL1740
      ALFA(3)=0.                                                        SHEL1750
      CON=EE(1)/(1.0-EE(2)*EE(2))                                       SHEL1760
      CM(1,1)=CON                                                       SHEL1770
      CM(1,2)=CON*EE(2)                                                 SHEL1780
      CM(2,1)=CM(1,2)                                                   SHEL1790
      CM(2,2)=CON                                                       SHEL1800
      CM(3,3)=EE(1)*0.5/(1.0+EE(2))                                     SHEL1810
      CM(1,3)=0.                                                        SHEL1820
      CM(2,3)=0.                                                        SHEL1830
      CM(3,1)=0.                                                        SHEL1840
      CM(3,2)=0.                                                        SHEL1850
      E4=EE(4)                                                          SHEL1860
      E5=EE(5)                                                          SHEL1870
      E6=EE(6)                                                          SHEL1880
C*******************************************************************************SHEL1890
C-----FORM SHELL GLOBAL STIFFNESS MATRIX,MASS MATRIX,STRESS/DISPLACEMENTSHEL1900
C-----FORM SHELL ELEMENT MATRICES                                       SHEL1910
C*******************************************************************************SHEL1920
      AREA=0.0                                                          SHEL1930
      CALL QTSHEL(AREA,ND)                                              SHEL1940
      NN=ND*ND*NU                                                       SHEL1950
      CALL REARAN(S,S,30,30,2,ND,ND,NU,NN)                              SHEL1960
      NN=NS*ND*NU                                                       SHEL1970
      CALL REARAN(ST,ST,6,30,2,NS,ND,NU,NN)                             SHEL1980
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      NN=ND*4*NV                                                        SHEL1990
      CALL REARAN(P,P,24,4,3,ND,4,NV,NN)                                SHEL2000
  900 CONTINUE                                                          SHEL2010
      IWT(IDV)=IWT(IDV)+AREA*RHO*FRC                                    SHEL2020
C*********************************************************************SHEL2030
C-----FORM LM ARRAY AND COMPUTE BANDWIDTH                               SHEL2040
C*********************************************************************SHEL2050
      DO 410 I=1,NEN                                                    SHEL2060
      J=6*I-6                                                           SHEL2070
      M=IX(I)                                                           SHEL2080
      DO 410 K=1,6                                                      SHEL2090
  410 LM(J+K)=ID(M,K)                                                   SHEL2100
      CALL CALBAN(NDOF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,FRC)         SHEL2110
      WRITE(IR) NI,E4,E5,E6,BET                                         SHEL2120
      WRITE(IW,2004) NEL,IX,IMAT,IDV,PRESS,REFT,FRC,BETA,NDOF           SHEL2130
      DO 450 MM=1,NEN                                                   SHEL2140
  450 IX(MM)=IX(MM)+INC                                                 SHEL2150
  500 CONTINUE                                                          SHEL2160
      N=IEL+1                                                           SHEL2170
      IF(N.LE.NUME) GO TO 100                                           SHEL2180
      RETURN                                                            SHEL2190
  600 WRITE(IW,2005) N                                                  SHEL2200
      STOP                                                              SHEL2210
 1000 FORMAT(2I5 ,F10.0 )                                               SHEL2220
 1001 FORMAT(8I5,4F10.0)                                                SHEL2230
 1002 FORMAT (4F10.0)                                                   SHEL2240
 1003 FORMAT(7F10.0)                                                    SHEL2250
 2000 FORMAT (50H1T H I N   P L A T E / S H E L L   E L E M E N T S. // SHEL2260
     2        22H NUMBER OF ELEMENTS  =, I5 /                          SHEL2270
     3        22H NUMBER OF MATERIALS =, I5 /,                         SHEL2280
     4        22H NUMBER OF TEMP CARDS=, I5/,                          SHEL2290
     5        22H CONSTRN CODE        =,  I5//  )                      SHEL2300
 2001 FORMAT (24H MATERIAL PROPERTY TABLE, //                           SHEL2310
     1       12H MATERIAL NUM OF   SPECIFIC    TEMP         YOUNGS    POSHEL2320
     2ISSONS'S    COEFFT OF  /------------ALLOWABLE STRESSES-----------SHEL2330
     3-/   / 11H NUMBER   TEMP      WEIGHT                  MODULUS     SHEL2340
     4RATIO       THERM EXPN    TENSION      COMPRESSION       SHEAR  )SHEL2350
 2002 FORMAT(I5,I9,F10.5)                                               SHEL2360
 2003 FORMAT(/32H THIN  PLATE/SHELL  ELEMENT DATA, // 8H ELEMENT, 32X,  SHEL2370
     1 8HMATERIAL,4X,7HDES VAR,4X,6HNORMAL,4X,9HREFERENCE ,5X,7HDES VAR,SHEL2380
     ,5X,4HBETA,8X,4HBAND  /                                            SHEL2390
     2 7H NUMBER,2X,6HNODE-I,2X,6HNODE-J,1X,6HNODE-K,2X,6HNODE-L,       SHEL2400
     3          3X,6HNUMBER,5X,6HNUMBER,4X,8HPRESSURE,2X,11HTEMPERATURE,SHEL2410
     4 3X,8HERACTION,16X,5HWIDTH /)                                     SHEL2420
 2004 FORMAT(I5,4I8,2I9,3X,4F12.4 ,I10)                                 SHEL2430
 2005 FORMAT (19H0CARD FOR ELEMENT (,I5,14H) IS IN ERROR.. / 1X)        SHEL2440
 2006 FORMAT(/30H ELEMENT LOAD CASE MULTIPLIERS. // 13H ELEMENT LOAD,   SHEL2450
     1 4X,8HPRESSURE,5X,7HTHERMAL,13X,2HX-,13X,2HY-,13X,2HZ-, /         SHEL2460
     2 13H  CASE NUMBER,17X,7HEFFECTS, 3(3X,12HACCELERATION), / 1X)     SHEL2470
 2007 FORMAT (6X,I1,6X,2F12.3,3F15.3)                                   SHEL2480
 2008 FORMAT(26X,F10.3,1PE14.5,0PF10.3,1PE14.5,0P3F14.2)                SHEL2490
 2009 FORMAT(1H+,25X,F10.3,1PE14.5,0PF10.3,1PE14.5,0P3F14.2)            SHEL2500
      END                                                               SHEL2510
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      SUBROUTINE DTSHEL(AREAA,ND)                                        SHEL2520
C*********************************************************************SHEL2530
C-----THIS SUBROUTINE EVALUATES                                          SHEL2540
C                     STIFFNESS MATRIX                                   SHEL2550
C                     NODAL FORCE VECTOR DUE TO THERMAL STRAINS          SHEL2560
C                     MASS MATRIX                                        SHEL2570
C                     STRESS/DISPLACEMENT TRANSFORMATION MATRIX          SHEL2580
C                     (MEMBRANE AND BENDING)                             SHEL2590
C                     NODAL FORCE VECTOR DUE TO DISTRIBUTED LATERAL LOADSHEL2600
C     AND STRESS CORRECTION MATRIX DUE TO THERMAL STRAINS                SHEL2610
C     OF A SHALLOW QUADRILATERAL SHELL ELEMENT ASSEMBLED WITH FOUR FLAT  SHEL2620
C     TRIANGLES OR OF A SINGLE TRIANGULAR SHELL ELEMENT                  SHEL2630
C-----S1   : UNIT STIFFNESS PROPORTIONAL TO THICKNESS                    SHEL2640
C            (DUE TO MEMBRANE ACTION)                                    SHEL2650
C-----S2   : UNIT STIFFNESS PROPORTIONAL TO (THICKNESS)**3               SHEL2660
C            (DUE TO BENDING ACTION)                                     SHEL2670
C-----P1   : UNIT NODAL FORCE VECTOR PROPORTIONAL TO THICKNESS           SHEL2680
C            (DUE TO GRAVITY LOADS AND DUE TO MEAN TEMPERATURE DIFFERENCESHEL2690
C-----P2   : UNIT NODAL FORCE VECTOR  AND IS CONSTANT                    SHEL2700
C            (DUE TO NORMAL PRESSURE LOADS)                              SHEL2710
C-----P3   : UNIT NODAL FORCE VECTOR PROPORTIONAL TO (THICKNESS)**3      SHEL2720
C            (DUE TOTEMPERATURE GRADIENT ACROSS THICKNESS)               SHEL2730
C-----XM   : MASS MATRIX PROPORTIONAL TO THICKNESS                       SHEL2740
C-----SA1  : UNIT STRESS MATRIX PROPORTIONAL TO THICKNESS                SHEL2750
C            (DUE TO MEMBRANE ACTION)                                    SHEL2760
C-----SA2  : UNIT STRESS MATRIX PROPORTIONAL TO (THICKNESS)**3           SHEL2770
C            (DUE TO BENDING ACTION)                                     SHEL2780
C-----TT1  : UNIT STRESS CORRECTION VECTOR PROPORTIONAL TO THICKNESS     SHEL2790
C            (DUE TO MEAN TEMPERATURE DIFFERENCE - MEMBRANE STRESSES)    SHEL2800
C-----TT2  : STRESS CORRECTION VECTOR PROPORTIONAL TO (THICKNESS)**3      SHEL2810
C            (DUE TO TEMPERATURE GRADIENT ACROSS THICKNESS)              SHEL2820
C*********************************************************************SHEL2830
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHEL2840
      COMMON/JUNK/                                                       SHEL2850
     1 R1(30),R2(30),ST1(6),ST2(6),TD(3,3), X(5), Y(5), Z(5),            SHEL2860
     2 CM(3,3),ALFA(3),RHO ,NEN,NTRI,IX(4),IE(4),PRESS,REF1,TEMP,        SHEL2870
     3 DTEMP,EMUL(5,4),EE(12)                                           SHEL2880
      COMMON/EM/ELM(24),S1(30,30),S2(30,30),P1(24,4),P2(24,4),P3(24,4),  SHEL2890
     1 XM(24),SA1(6,30),SA2(6,30),TT1(6,4),TT2(6,4) ,EM1                SHEL2900
      COMMON/COMPL/ A(3),B(3),ET(9),ST(9,9),T1(9),T2(9),T3(9),AREA,      SHEL2910
     1 CT(3,9),SMI(3),BMI(3),LOC(3),ICOMP(481)                          SHEL2920
      DIMENSION IPERMO(4),EMM(2520)                                      SHEL2930
      EQUIVALENCE (EMM,S1)                                               SHEL2940
      DATA IPERMO /2,3,4,1/                                              SHEL2950
      WG=1.0                                                             SHEL2960
      N3=3                                                               SHEL2970
      IF(NTRI.EQ.1) GO TO  50                                            SHEL2980
      WG=0.25                                                            SHEL2990
      N3=5                                                               SHEL3000
   50 DO 150 I=1,30                                                      SHEL3010
      R1(I)=0.                                                           SHEL3020
  150 R2(I)=0.                                                           SHEL3030
      DO 151 I=1,2520                                                    SHEL3040
  151 EMM(I)=0.                                                          SHEL3050
C*********************************************************************SHEL3060
C-----COMPUTE DIRECTION COSINE MATRIX TO BE LOCAL ELEMENT SYSTEM         SHEL3070
C*********************************************************************SHEL3080
      CALL DDCOS (NTRI,X,Y,Z,TD)                                         SHEL3090
C*********************************************************************SHEL3100
C-----THERMAL STRESS CORRECTION MATRIX                                   SHEL3110
```

```
C*****************************************************************************SHEL 3120
      DT=DTEMP/12.                                                               SHEL 3130
      DO 160 I=1,3                                                               SHEL 3140
      CC=CM(I,1)*ALFA(1)+CM(I,2)*ALFA(2)+CM(I,3)*ALFA(3)                         SHEL 3150
      SMT(I) =-CC*TEMP                                                           SHEL 3160
      BMT(I) =-CC*DT                                                             SHEL 3170
      DO 160 J=1,4                                                               SHEL 3180
      TT1(I,J)=SMT(I)*EMUL(2,J)                                                  SHEL 3190
  160 TT2(I+3,J)=BMT(I)*EMUL(2,J)                                                SHEL 3200
C*****************************************************************************SHEL 3210
C-----LOOP OVER THE NTRI TRIANGLE COMPONENTS                                     SHEL 3220
C*****************************************************************************SHEL 3230
      DO 700  NT = 1,NTRI                                                        SHEL 3240
      N1=NT                                                                      SHEL 3250
      N2= IPERMQ(NT)                                                             SHEL 3260
      LOC(1)= N1*6-6                                                             SHEL 3270
      LOC(2)= N2*6-6                                                             SHEL 3280
      LOC(3)= N3*6-6                                                             SHEL 3290
C*****************************************************************************SHEL 3300
C-----COMPUTE DIRECTION COSINES OF LOCAL TRIANGLE SYSTEM                         SHEL 3310
C     AND THE TRIANGLE PROJECTIONS A,B ONTO IT                                   SHEL 3320
C-----FORM TRANSFORMATIONS BETWEEN ELEMENT AND NODAL SYSTEMS                     SHEL 3330
C*****************************************************************************SHEL 3340
      CALL TDCOS(N1,N2,N3,X,Y,Z,A,B,T1,T2,T3,TD,NTRI)                            SHEL 3350
C*****************************************************************************SHEL 3360
C-----FORM MASS MATRIX AND NODAL FORCE VECTOR DUE TO NORMAL PRESSURE             SHEL 3370
C     AND GRAVITY LOADS IN GLOBAL COORDINATES                                    SHEL 3380
C*****************************************************************************SHEL 3390
      AREA=(A(3)*B(2)-A(2)*B(3))*0.5                                             SHEL 3400
      AREAA=AREAA+AREA                                                           SHEL 3410
      IF(NTRI.EQ.1) GO TO 345                                                    SHEL 3420
      FAC=AREA*PRESS*0.5                                                         SHEL 3430
      XMM= AREA*RHO *0.5                                                         SHEL 3440
      DO 340 I=1,2                                                               SHEL 3450
      K=LOC(I)                                                                   SHEL 3460
      DO 340 J=1,3                                                               SHEL 3470
      K=K+1                                                                      SHEL 3480
      DO 341 L=1,4                                                               SHEL 3490
      P1 (K,L)= P1 (K,L)+XMM*EMUL(J+2,L)                                         SHEL 3500
  341 P2 (K,L)= P2 (K,L)+ FAC*EMUL(I,L)*T3(J)                                    SHEL 3510
  340 XM(K)=XM(K)+XMM                                                            SHEL 3520
      GO TO 350                                                                  SHEL 3530
  345 FAC= AREA*PRESS/3.                                                         SHEL 3540
      XMM=AREA*RHO/3.0                                                           SHEL 3550
      DO 360 I=1,3                                                               SHEL 3560
      K=LOC(I)                                                                   SHEL 3570
      DO 360 J=1,3                                                               SHEL 3580
      K=K+1                                                                      SHEL 3590
      DO 361 L=1,4                                                               SHEL 3600
      P1 (K,L)= P1 (K,L)+XMM*EMUL(J+2,L)                                         SHEL 3610
  361 P2 (K,L)= P2 (K,L)+ FAC*EMUL(I,L)*T3(J)                                    SHEL 3620
  360 XM (K)=XM(K)+XMM                                                           SHEL 3630
  350 CONTINUE                                                                   SHEL 3640
C*****************************************************************************SHEL 3650
C-----MEMBRANE CONTRIBUTION                                                      SHEL 3660
C*****************************************************************************SHEL 3670
      CALL SLST    (CM)                                                          SHEL 3680
C*****************************************************************************SHEL 3690
C-----LOCAL TO GLOBAL COORDINATE TRANSFORMATION OF TRIANGLE ELEMENT              SHEL 3700
C     MEMBRANE STIFFNESS                                                         SHEL 3710
```

```
C*************************************************************************SHEL 3720
      LT=0                                                                SHEL 3730
      DO 400 JJ=1,3                                                       SHEL 3740
      J = JJ + JJ                                                         SHEL 3750
      M = LOC(JJ)                                                         SHEL 3760
      DO 400 L=1,3                                                        SHEL 3770
      M = M + 1                                                           SHEL 3780
      LT=LT+1                                                             SHEL 3790
      C1=T1(LT)                                                           SHEL 3800
      C2=T2(LT)                                                           SHEL 3810
      KT=0                                                                SHEL 3820
      DO 390 II=1,JJ                                                      SHEL 3830
      I = II + II                                                         SHEL 3840
      KK=3                                                                SHEL 3850
      IF (II.EQ.JJ)  KK = L                                               SHEL 3860
      H1 = ST(I-1,J-1)*C1 + ST(I-1,J)*C2                                  SHEL 3870
      H2 = ST(I  ,J-1)*C1 + ST(I  ,J)*C2                                  SHEL 3880
      N = LOC(II)                                                         SHEL 3890
      DO 390 K=1,KK                                                       SHEL 3900
      N = N + 1                                                           SHEL 3910
      KT=KT+1                                                             SHEL 3920
      SO= S1(N,M)+T1(KT)*H1+T2(KT)*H2                                     SHEL 3930
      S1(N,M)=SO                                                          SHEL 3940
  390 S1(M,N)=SO                                                          SHEL 3950
  400 CONTINUE                                                            SHEL 3960
C*************************************************************************SHEL 3970
C-----LOCAL TO GLOBAL COORDINATE TRANSFORMATION OF STRESS MATRIX AND       SHEL 3980
C     THERMAL LOAD VECTOR                                                 SHEL 3990
C*************************************************************************SHEL 4000
      DO 410 JJ=1,3                                                       SHEL 4010
      M=LOC(JJ)                                                           SHEL 4020
      J=JJ+JJ                                                             SHEL 4030
      DO 410 L=1,3                                                        SHEL 4040
      M = M+1                                                             SHEL 4050
      R1(M)=R1(M)+T1(L)*FT(J-1)+T2(L)*FT(J)                               SHEL 4060
      DO 410 K=1,3                                                        SHEL 4070
  410 SA1(K,M)=SA1(K,M)+(CT(K,J-1)*T1(L) +CT(K,J)*T2(L))*WG               SHEL 4080
C*************************************************************************SHEL 4090
C-----PLATE BENDING CONTRIBUTION                                          SHEL 4100
C*************************************************************************SHEL 4110
      CALL SLCCT(CM,NTRI)                                                 SHEL 4120
C*************************************************************************SHEL 4130
C-----LOCAL TO GLOBAL TRANSFORMATION OF TRIANGLE ELEMENT                  SHEL 4140
C     BENDING STIFFNESS                                                   SHEL 4150
C*************************************************************************SHEL 4160
      DO 500  JJ = 1,3                                                    SHEL 4170
      JT = 3*JJ-3                                                         SHEL 4180
      J = JT + 1                                                          SHEL 4190
      DO 480  II = 1,JJ                                                   SHEL 4200
      IT = 3*II-3                                                         SHEL 4210
      I = IT + 1                                                          SHEL 4220
      KK=6                                                                SHEL 4230
      DO 480 L=1,6                                                        SHEL 4240
      IF (II.EQ.JJ)  KK = L                                               SHEL 4250
      M = LOC(JJ) + L                                                     SHEL 4260
      L3 = L - 3                                                          SHEL 4270
      IF (L3.GT.0)  GO TO 460                                             SHEL 4280
      C3=T3(JT+L)                                                         SHEL 4290
      H1 = ST(I  ,J)*C3                                                   SHEL 4300
      H2 = ST(I+1,J)*C3                                                   SHEL 4310
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```
      H3 = ST(I+2,J)*C3                                                 SHEL4320
      GO TO 470                                                         SHEL4330
  460 C1=T1(JT+L3)                                                      SHEL4340
      C2=T2(JT+L3)                                                      SHEL4350
      H1 = ST(I  ,J+1)*C1 + ST(I  ,J+2)*C2                              SHEL4360
      H2 = ST(I+1,J+1)*C1 + ST(I+1,J+2)*C2                              SHEL4370
      H3 = ST(I+2,J+1)*C1 + ST(I+2,J+2)*C2                              SHEL4380
  470 M = LOC(II)                                                       SHEL4390
      DO 480  K = 1,KK                                                  SHEL4400
      M = M + 1                                                         SHEL4410
      K3 = K - 3                                                        SHEL4420
      K1 = II + K                                                       SHEL4430
      K2 = IT + K3                                                      SHEL4440
      IF (K3.LE.0)  SO =S2(M,M) + T3(K1) *H1                            SHEL4450
      IF (K3.GT.0)  SO =S2(M,M) + T1 (K2)*H2 + T2 (K2)*H3               SHEL4460
      S2(M,M)= SO                                                       SHEL4470
  480 S2(M,M)= SO                                                       SHEL4480
  500 CONTINUE                                                          SHEL4490
C***********************************************************************SHEL4500
C-----LOCAL TO GLOBAL TRANSFORMATION OF MOMENT RESULTANT MATRIX AND      SHEL4510
C     THERMAL LOAD VECTOR                                               SHEL4520
C***********************************************************************SHEL4530
      DO 680 JJ=1,3                                                     SHEL4540
      M=LOC(JJ)                                                         SHEL4550
      J=(JJ-1)*3+1                                                      SHEL4560
      DO 686 L=1,3                                                      SHEL4570
      M = M+1                                                           SHEL4580
      R2(M)=R2(M)+FT(J)*T3(L)                                           SHEL4590
      DO 686 K=1,3                                                      SHEL4600
  686 SA2(K+3,M)=SA2(K+3,M)+CT(K,J  )*T3(L)*WG                          SHEL4610
      DO 680 L=1,3                                                      SHEL4620
      M=M+1                                                             SHEL4630
      R2(M)=R2(M)+FT(J+1)*T1(L)+FT(J+2)*T2(L)                           SHEL4640
      DO 680 K=1,3                                                      SHEL4650
  680 SA2(K+3,M)=SA2(K+3,M)+(CT(K,J+1 )*T1(L)  +CT(K,J+2 )*T2(L)  )*WG  SHEL4660
  700 CONTINUE                                                          SHEL4670
      IF(NTRI.EQ.1) GO TO 900                                           SHEL4680
C***********************************************************************SHEL4690
C-----CHECK FOR POSSIBLE INTERNAL STIFFNESS SINGULARITY (FLAT           SHEL4700
C     OR NEARLY FLAT QUADRILATERAL) AND TRANSFORM STIFFNESS AT 5TH NODE SHEL4710
C     TO GLOBAL COORDINATES                                             SHEL4720
C***********************************************************************SHEL4730
      IF(S1(27,27).GT.(S1(25,25)+S1(26,26))*1.0E-07) GO TO 690          SHEL4740
      DO 691 I=1,27                                                     SHEL4750
      S1(I,27)=0.0                                                      SHEL4760
  691 S1(27,I)=0.0                                                      SHEL4770
  690 DO 510 II=1,27                                                    SHEL4780
      DO 511 J=1,3                                                      SHEL4790
  511 FT(J)=S1(II,25)*TD(1,J)+S1(II,26)*TD(2,J)+S1(II,27)*TD(3,J)       SHEL4800
      DO 510 J=1,3                                                      SHEL4810
  510 S1(II,J+24)=FT(J)                                                 SHEL4820
      DO 520 JJ=25,27                                                   SHEL4830
      DO 521 I=1,3                                                      SHEL4840
  521 FT(I)=TD(1,I)*S1(25,JJ)+TD(2,I)*S1(26,JJ)+TD(3,I)*S1(27,JJ)       SHEL4850
      DO 520 I=1,3                                                      SHEL4860
  520 S1(24+I,JJ)=FT(I)                                                 SHEL4870
      DO 530 I=1,24                                                     SHEL4880
      DO 530 J=25,27                                                    SHEL4890
  530 S1(J,I)=S1(I,J)                                                   SHEL4900
      CALL TRANS(S2,TD,F1,FT(4),FT(7))                                  SHEL4910
```

```
C*************************************************************************SHEL 4920
C-----CONDENSATION OF INTERNAL DEGREES OF FREEDOM                          SHEL 4930
C*************************************************************************SHEL 4940
      CALL CONDEN (1,3,S1,R1,SA1,ST1)                                      SHEL 4950
      CALL CONDEN (4,6,S2,R2,SA2,ST2)                                      SHEL 4960
      DO 85 I=1,6                                                          SHEL 4970
      DO 851 J=1,4                                                         SHEL 4980
      TT1(I,J)=TT1(I,J)+ST1(I)*EMUL(2,J)                                   SHEL 4990
  851 TT2(I,J)=TT2(I,J)+ST2(I)*EMUL(2,J)                                   SHEL 5000
  900 DO 850 I=1,NN                                                        SHEL 5010
      DO 850 J=1,4                                                         SHEL 5020
      P1 (I,J)=P1 (I,J)+R1(I)*EMUL(2,J)                                    SHEL 5030
  850 P3 (I,J)=R2 (I)*EMUL(2,J)                                            SHEL 5040
      RETURN                                                               SHEL 5050
      END                                                                  SHEL 5060
```

```
      SUBROUTINE CONDEN(NN,MM,S,R,SA,ST)                                   SHEL 5070
C*************************************************************************SHEL 5080
C-----CONDENSATION OF INTERNAL DEGREES OF FREEDOM                          SHEL 5090
C*************************************************************************SHEL 5100
      IMPLICIT REAL*8 (A-H,O-Z)                                            SHEL 5110
      DIMENSION S(30,30),R(30),SA(6,30),ST(6)                              SHEL 5120
      DO 850 I=1,6                                                         SHEL 5130
  850 ST(I)=0.                                                             SHEL 5140
      DO 800 J=1,6                                                         SHEL 5150
      L=30-J                                                               SHEL 5160
      M=L+1                                                                SHEL 5170
      PIV=S(M,M)                                                           SHEL 5180
      IF(PIV.LE.0) GO TO 800                                               SHEL 5190
      RL=R(M)/PIV                                                          SHEL 5200
      DO 820 K=1,L                                                         SHEL 5210
      R(K)=R(K)-S(K,M)*RL                                                  SHEL 5220
      SS=S(M,K)/PIV                                                        SHEL 5230
      DO 830 I=1,K                                                         SHEL 5240
  830 S(K,I)=S(K,I)-S(M,I)*SS                                              SHEL 5250
      DO 820 I=NN,MM                                                       SHEL 5260
  820 SA (I,K)=SA (I,K)-SA (I,M)*SS                                        SHEL 5270
      DO 810 I=NN,MM                                                       SHEL 5280
  810 ST(I)=ST(I)-SA(I,M)*RL                                               SHEL 5290
  800 CONTINUE                                                             SHEL 5300
      DO  900 I=2,24                                                       SHEL 5310
      II=I-1                                                               SHEL 5320
      DO 900 J=1,II                                                        SHEL 5330
  900 S(J,I)=S(I,J)                                                        SHEL 5340
      RETURN                                                               SHEL 5350
      END                                                                  SHEL 5360
```

```
      SUBROUTINE TRANS(S,TO,C1,C2,C3)                                   SHEL 5370
C*********************************************************************SHEL 5380
C-----TRANSFORM THE STIFFNESS MATRIX AT 5TH NODE TO GLOBAL COORDINATES SHEL 5390
C*********************************************************************SHEL 5400
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 5410
      DIMENSION S(30,30),TO(3,3),C1(3),C2(3),C3(3)                      SHEL 5420
      IF(S (25,25).GT. S (27,27)*1.0E-07) GO TO 692                     SHEL 5430
      DO 693 I=1,30                                                     SHEL 5440
      S (I,25)=0.0                                                      SHEL 5450
  693 S (25,I)=0.0                                                      SHEL 5460
  692 IF(S (26,26).GT.S (27,27)*1.0E-07) GO TO 694                      SHEL 5470
      DO 695 I=1,30                                                     SHEL 5480
      S (I,26)=0.0                                                      SHEL 5490
  695 S (26,I)=0.0                                                      SHEL 5500
  694 IF(S (30,30).GT.(S (29,29)+S (28,28))*1.0E-08) GO TO 730          SHEL 5510
      DO 710 I=1,30                                                     SHEL 5520
      S (I,30)=0.                                                       SHEL 5530
  710 S (30,I)=0.                                                       SHEL 5540
  730 DO 10 II=1,30                                                     SHEL 5550
      DO 11 I=1,3                                                       SHEL 5560
      C1(I)=S(II,25)*TO(1,I)+S(II,26)*TO(2,I)+S(II,27)*TO(3,I)          SHEL 5570
   11 C2(I)=S(II,28)*TO(1,I)+S(II,29)*TO(2,I)+S(II,30)*TO(3,I)          SHEL 5580
      DO 10 J=1,3                                                       SHEL 5590
      S(II,J+24)=C1(J)                                                  SHEL 5600
   10 S(II,J+27)=C2(J)                                                  SHEL 5610
      DO 20 JJ=25,27                                                    SHEL 5620
      J3=JJ+3                                                           SHEL 5630
      DO 21 I=1,3                                                       SHEL 5640
      T1=TO(1,I)                                                        SHEL 5650
      T2=TO(2,I)                                                        SHEL 5660
      T3=TO(3,I)                                                        SHEL 5670
      C1(I)=T1*S(25,JJ)+T2*S(26,JJ)+T3*S(27,JJ)                         SHEL 5680
      C2(I)=T1*S(25,J3)+T2*S(26,J3)+T3*S(27,J3)                         SHEL 5690
   21 C3(I)=T1*S(28,J3)+T2*S(29,J3)+T3*S(30,J3)                         SHEL 5700
      DO 20 I=1,3                                                       SHEL 5710
      S(I+24,JJ)=C1(I)                                                  SHEL 5720
      S(I+24,J3)=C2(I)                                                  SHEL 5730
      S(J3,I+24)=C2(I)                                                  SHEL 5740
   20 S(I+27,J3)=C3(I)                                                  SHEL 5750
      DO 30 I=1,24                                                      SHEL 5760
      DO 30 J=25,30                                                     SHEL 5770
   30 S(J,I)=S(I,J)                                                     SHEL 5780
      RETURN                                                            SHEL 5790
      END                                                               SHEL 5800
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```
      SUBROUTINE SLST (C  )                                                 SHEL 5810
C*************************************************************************SHEL 5820
C-----THIS SUBROUTINE FORMS THE STIFFNESS MATRIX ,THERMAL LOAD VECTOR,      SHEL 5830
C     AND STRESS MATRIX OF A CONSTANT STRAIN TRIANGLE     WITH              SHEL 5840
C     LINEAR ELASTIC ANISOTROPIC PROPERTIES                                 SHEL 5850
C*************************************************************************SHEL 5860
      IMPLICIT REAL*8 (A-H,O-Z)                                             SHEL 5870
      COMMON/COMPL/A(3),B(3),FT(9),ST(9,9),T1(9),T2(9),T3(9),AREA,          SHEL 5880
     1 CT(3,9),SMT(3),BMT(3),LOC(3),ICOMP(48)                               SHEL 5890
      DIMENSION C(3,3)                                                      SHEL 5900
      FAC=0.25/AREA                                                         SHEL 5910
      FAC1=0.5/AREA                                                         SHEL 5920
      C11 = C(1,1)*FAC                                                      SHEL 5930
      C22 = C(2,2)*FAC                                                      SHEL 5940
      C33 = C(3,3)*FAC                                                      SHEL 5950
      C12 = C(1,2)*FAC                                                      SHEL 5960
      C13 = C(1,3)*FAC                                                      SHEL 5970
      C23 = C(2,3)*FAC                                                      SHEL 5980
      DO 200 J=1,3                                                          SHEL 5990
      L=I+J                                                                 SHEL 6000
C*************************************************************************SHEL 6010
C-----THERMAL LOAD VECTOR                                                   SHEL 6020
C*************************************************************************SHEL 6030
      FT(L-1)=(-B(J)*SMT(1)-A(J)*SMT(3))*0.5                                SHEL 6040
      FT(L  )=(-A(J)*SMT(2)-B(J)*SMT(3))*0.5                                SHEL 6050
C*************************************************************************SHEL 6060
C-----STRESS DISPLACEMENT TRANSFORMATION MATRIX                             SHEL 6070
C*************************************************************************SHEL 6080
      DO 300 I=1,3                                                          SHEL 6090
      CT(I,L-1)= (C(I,1)*B(J)+C(I,3)*A(J))*FAC1                             SHEL 6100
  300 CT(I,L) = (C(I,2)*A(J)+C(I,3)*B(J))*FAC1                              SHEL 6110
C*************************************************************************SHEL 6120
C-----STIFFNESS MATRIX IN TRIANGLE LOCAL COORDINATES                        SHEL 6130
C*************************************************************************SHEL 6140
      DO 200 I=1,J                                                          SHEL 6150
      K=I+I                                                                 SHEL 6160
      AA=A(I)*A(J)                                                          SHEL 6170
      AB=A(I)*B(J)                                                          SHEL 6180
      BB=B(I)*B(J)                                                          SHEL 6190
      BA=B(I)*A(J)                                                          SHEL 6200
      ABA=AB+BA                                                             SHEL 6210
      ST(K-1,L-1)=C11*BB+C13*ABA+C33*AA                                     SHEL 6220
      ST(K-1,L)=C12*BA+C13*BB+C23*AA+C33*AB                                 SHEL 6230
      ST(K,L-1)= C12*AB+C13*BB+C23*AA+C33*BA                                SHEL 6240
  200 ST(K,L)= C22*AA+C23*ABA+C33*BB                                        SHEL 6250
      DO 400 I=3,6                                                          SHEL 6260
      DO 400 J=1,I                                                          SHEL 6270
  400 ST(I,J)=ST(J,I)                                                       SHEL 6280
      RETURN                                                                SHEL 6290
      END                                                                   SHEL 6300
```

```
      SUBROUTINE SLCCT(CM,NTRI)                                          SHEL6310
C*********************************************************************SHEL6320
C-----THIS SUBROUTINE FORMS THE PLATE BENDING STIFFNESS AND THE          SHEL6330
C     CONSTITENT LOAD VECTOR DUE TO THERMAL LOADS AND STRESS             SHEL6340
C     TRANSFORMATION MATRIX OF A LINEAR CURVATURE COMPATIBLE TRIANGLE    SHEL6350
C     WITH 6 NODAL POINTS . MID SIDE NODES ARE ELIMINATED BY ASSUMING    SHEL6360
C     NORMAL SLOPE AT THE MID SIDE NODE TO BE AVERAGE OF THE ONES AT TWOSHEL6370
C     ADJACENT CORNERS.                                                  SHEL6380
C*********************************************************************SHEL6390
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHEL6400
      COMMON/COMPL/A(3),B(3),FT(9),ST(9,9),T1(9),T2(9),T3(9),AREA,       SHEL6410
     1 CT(3,9),SMT(3),AMT(3),LOC(3),JUN,U(3),TX(3),TY(3),Q(3,6),P(2),9),SHEL6420
     2 G(21),HT(3)                                                      SHEL6430
      DIMENSION IPERM(3) ,CM(3,3)                                        SHEL6440
      DATA IPERM/2,3,1/                                                  SHEL6450
      FAC1=AREA/432.                                                     SHEL6460
      FAC2=1./12.                                                        SHEL6470
      DO 150 I=1,3                                                       SHEL6480
      J = IPERM(I)                                                       SHEL6490
      K = IPERM(J)                                                       SHEL6500
      X= A(I)**2+B(I)**2                                                 SHEL6510
      U(I)= -(A(I)*A(J)+B(I)*B(J))/X                                     SHEL6520
      X=DSQRT(X)                                                         SHEL6530
      Y=4.*AREA/X                                                        SHEL6540
      HT(I) =2.*Y                                                        SHEL6550
      TX(I)= Y*A(I)/X                                                    SHEL6560
      TY(I)=-Y*B(I)/X                                                    SHEL6570
      A1=0.5*A(I)/AREA                                                   SHEL6580
      A2=0.5*A(J)/AREA                                                   SHEL6590
      B1=0.5*B(I)/AREA                                                   SHEL6600
      B2=0.5*B(J)/AREA                                                   SHEL6610
      Q(1,I)   =  B1*B1                                                  SHEL6620
      Q(2,I)   =  A1*A1                                                  SHEL6630
      Q(3,I)   =  2.*A1*B1                                               SHEL6640
      Q(1,I+3) =  2.*B1*B2                                               SHEL6650
      Q(2,I+3) =  2.*A1*A2                                               SHEL6660
      Q(3,I+3) =  2.*(A1*B2+A2*B1)                                       SHEL6670
  150 CONTINUE                                                           SHEL6680
C*********************************************************************SHEL6690
C-----CURVATURE DISPLACEMENT RELATION FOR THREE TRIANGULAR REGIONS      SHEL6700
C*********************************************************************SHEL6710
      DO 200 I=1,3                                                       SHEL6720
      J=IPERM(I)                                                         SHEL6730
      K=IPERM(J)                                                         SHEL6740
      II=3*I                                                             SHEL6750
      JJ=3*J                                                             SHEL6760
      KK=3*K                                                             SHEL6770
      A1= A(I)                                                           SHEL6780
      A2= A(J)                                                           SHEL6790
      A3= A(K)                                                           SHEL6800
      B1=B(I)                                                            SHEL6810
      B2=B(J)                                                            SHEL6820
      B3=B(K)                                                            SHEL6830
      U1=U(I)                                                            SHEL6840
      U2=U(J)                                                            SHEL6850
      U3=U(K)                                                            SHEL6860
      W1=1.-U1                                                           SHEL6870
      W2=1.-U2                                                           SHEL6880
      W3=1.-U3                                                           SHEL6890
      B1D=B1+B1                                                          SHEL6900
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      B2D=B2+B2                                                          SHEL 6910
      B3D=B3+B3                                                          SHEL 6920
      A1D=A1+A1                                                          SHEL 6930
      A2D=A2+A2                                                          SHEL 6940
      A3D=A3+A3                                                          SHEL 6950
      C21 = B1-B3*U3          +TX(K)                                     SHEL 6960
      C31 = A1-A3*U3          +TY(K)                                     SHEL 6970
      C51 = B3*W3-B2          +TX(K)                                     SHEL 6980
      C61 = A3*W3-A2          +TY(K)                                     SHEL 6990
      C81 = B3-B2D-B2*U2      +TX(J)                                     SHEL 7000
      C91 = A3-A2D-A2*U2      +TY(J)                                     SHEL 7010
      C22=-B1D+B2*W2+B3*U3 + TX(J)-TX(K)                                 SHEL 7020
      C32=-A1D+A2*W2+A3*U3+TY(J)-TY(K)                                   SHEL 7030
      C52 = B2D-B3*W3-B1*U1   +TX(I)-TX(K)                               SHEL 7040
      C62 = A2D-A3*W3-A1*U1   +TY(I)-TY(K)                               SHEL 7050
      C82 = B1D-B3+B1*W1      +TX(I)                                     SHEL 7060
      C92 = A1D-A3+A1*W1      +TY(I)                                     SHEL 7070
      DO 200 N=1,3                                                       SHEL 7080
      L= 6*(I-1)+N                                                       SHEL 7090
      O11=O(N,I)                                                         SHEL 7100
      O22=O(N,J)                                                         SHEL 7110
      O33=O(N,K)                                                         SHEL 7120
      O12=O(N,I+3)                                                       SHEL 7130
      O23=O(N,J+3)                                                       SHEL 7140
      O31=O(N,K+3)                                                       SHEL 7150
      O2333=O23-O33                                                      SHEL 7160
      O3133=O31-O33                                                      SHEL 7170
      P(L    ,II-2) = 6.*(-O11+W2*O33+U2*O2333)                          SHEL 7180
      P(L    ,II-1) = C21*O23+C22*O33-B3D*O12+B2D*O31                    SHEL 7190
      P(L    ,II   ) = C31*O23+C32*O33-A3D*O12+A2D*O31                   SHEL 7200
      P(L    ,JJ-2) = 6.*(O22+W3*O2333)                                  SHEL 7210
      P(L    ,JJ-1) = C51*O2333+B3D*O22                                  SHEL 7220
      P(L    ,JJ   ) = C61*O2333+A3D*O22                                 SHEL 7230
      P(L    ,KK-2) = 6.*(1.+U2)*O33                                     SHEL 7240
      P(L    ,KK-1) = C81*O33                                            SHEL 7250
      P(L    ,KK   ) = C91*O33                                           SHEL 7260
      P(L+3  ,II-2) = 6.*(O11+U3*O3133)                                  SHEL 7270
      P(L+3  ,II-1) = C21*O3133-B3D*O11                                  SHEL 7280
      P(L+3  ,II   ) = C31*O3133-A3D*O11                                 SHEL 7290
      P(L+3  ,JJ-2) = 6.*(-O22+U1*O33+W3*O3133)                          SHEL 7300
      P(L+3  ,JJ-1) = C51*O31+C52*O33+B3D*O12-B1D*O23                    SHEL 7310
      P(L+3  ,JJ   ) = C61*O31+C62*O33+A3D*O12-A1D*O23                   SHEL 7320
      P(L+3  ,KK-2) = 6.*(1.+W1)*O33                                     SHEL 7330
      P(L+3  ,KK-1) = C82*O33                                            SHEL 7340
      P(L+3  ,KK   ) = C92*O33                                           SHEL 7350
      P(N+18,II-2) = 2.*(O11+U3*O12+W2*O31)                              SHEL 7360
      P(N+18,KK-1) = ( B1D-B2D)*O33+C82*O23+C81*O31)/3.                  SHEL 7370
      P(N+18,KK   ) = ((A1D-A2D)*O33+C92*O23+C91*O31)/3.                 SHEL 7380
  200 CONTINUE                                                           SHEL 7390
      DO 400 J=1,9                                                       SHEL 7400
      ET(J)=0.                                                           SHEL 7410
      DO 340 L=1,3                                                       SHEL 7420
      II=L                                                               SHEL 7430
      KK=L+18                                                            SHEL 7440
      P3=P(KK,J)                                                         SHEL 7450
      G(KK)=0.                                                           SHEL 7460
      DO 340 N=1,3                                                       SHEL 7470
      JJ=II+2                                                            SHEL 7480
      SUM=P(II,J)+P(JJ,J)+P3                                             SHEL 7490
       G(II)=SUM+P(II,J)                                                 SHEL 7500
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      G(JJ)=SUM+P(JJ,J)                                                 SHEL.7510
      G(KK)=G(KK)+SUM+P3                                                SHEL.7520
      FT(J)=FT(J)-SUM*BMT(L)*AREA/9.0                                   SHEL.7530
      II=II+6                                                           SHEL.7540
  340 CONTINUE                                                          SHEL.7550
      DO 360 N=1,19,3                                                   SHEL.7560
      G1=G(N)                                                           SHEL.7570
      G2=G(N+1)                                                         SHEL.7580
      G3=G(N+2)                                                         SHEL.7590
      G(N  )=CM(1,1)*G1+CM(1,2)*G2+CM(1,3)*G3                           SHEL.7600
      G(N+1)=CM(1,2)*G1+CM(2,2)*G2+CM(2,3)*G3                           SHEL.7610
  360 G(N+2)=CM(1,3)*G1+CM(2,3)*G2+CM(3,3)*G3                           SHEL.7620
      DO 390 I=1,J                                                      SHEL.7630
      X=0.                                                              SHEL.7640
      DO 380 N=1,21                                                     SHEL.7650
  380 X=X+G(N)*P(N,I)                                                   SHEL.7660
      X=X*FAC1                                                          SHEL.7670
      ST(I,J)=X                                                         SHEL.7680
  390 ST(J,I)=X                                                         SHEL.7690
  400 CONTINUE                                                          SHEL.7700
C*******************************************************************************SHEL.7710
C-----CURVATURE DISPLACEMENT - DISPLACEMENT RELATION AT ELEMENT CENTRE  SHEL.7720
C*******************************************************************************SHEL.7730
      IF(NTRI.EQ.1) GO TO 551                                           SHEL.7740
      DO 550 J=1,9                                                      SHEL.7750
      P(19,J)=(P(10,J)+P(13,J))*0.5                                     SHEL.7760
      P(20,J)=(P(11,J)+P(14,J))*0.5                                     SHEL.7770
  550 P(21,J)=(P(12,J)+P(15,J))*0.5                                     SHEL.7780
C*******************************************************************************SHEL.7790
C-----MOMENT - DISPLACEMENT RELATION                                    SHEL.7800
C*******************************************************************************SHEL.7810
  551 DO 600 I=1,3                                                      SHEL.7820
      DO 600 J=1,9                                                      SHEL.7830
      SUM=0.                                                            SHEL.7840
      DO 610 K=1,3                                                      SHEL.7850
  610 SUM=SUM+CM(I,K)*P(K+18,J)                                         SHEL.7860
  600 CT(I,J)=-FAC2*SUM                                                 SHEL.7870
      RETURN                                                            SHEL.7880
      END                                                               SHEL.7890
```

```
      SUBROUTINE TDCOS(N1,N2,N3,X,Y,Z,A,B,T1,T2,T3,T,NTRI)              SHEL 7900
C*************************************************************************SHEL 7910
C-----THIS SUBROUTINE COMPUTES THE DIRECTION COSINES OF THE LOCAL        SHEL 7920
C     SYSTEM AND THE PROJECTED DIMENSIONS OF A  SUBTRIANGLE  COMPONENT   SHEL 7930
C*************************************************************************SHEL 7940
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 7950
      DIMENSION X(5),Y(5),Z(5),A(3),B(3),T1(9),T2(9),T3(9),T(9)         SHEL 7960
      A1  = X(N1)-X(N3)                                                 SHEL 7970
      B1  = Y(N1)-Y(N3)                                                 SHEL 7980
      C1  =Z(N1)-Z(N3)                                                  SHEL 7990
      A2 = X(N2)-X(N3)                                                  SHEL 8000
      B2 = Y(N2)-Y(N3)                                                  SHEL 8010
      C2 = Z(N2)-Z(N3)                                                  SHEL 8020
      IF(NTRI.EQ.4) GO TO 300                                           SHEL 8030
      DO 350 I=1,3                                                      SHEL 8040
      T1(I)=T(I*3-2)                                                    SHEL 8050
      T1(I+3)=T1(I)                                                     SHEL 8060
      T1(I+6)=T1(I)                                                     SHEL 8070
      T2(I)=T(I*3-1)                                                    SHEL 8080
      T2(I+3)=T2(I)                                                     SHEL 8090
      T2(I+6)=T2(I)                                                     SHEL 8100
      T3(I)=T(I*3)                                                      SHEL 8110
      T3(I+3)=T3(I)                                                     SHEL 8120
  350 T3(I+6)=T3(I)                                                     SHEL 8130
      GO TO 400                                                         SHEL 8140
  300 T31 = B1*C2-B2*C1                                                 SHEL 8150
      T32 = C1*A2-C2*A1                                                 SHEL 8160
      T33 = A1*B2-A2*B1                                                 SHEL 8170
      S =DSQRT (T31**2+T32**2+T33**2)                                   SHEL 8180
      T31 = T31/S                                                       SHEL 8190
      T32 = T32/S                                                       SHEL 8200
      T33 = T33/S                                                       SHEL 8210
      T11= T33*T(5)-T32*T(8)                                            SHEL 8220
      T12= T31*T(8)-T33*T(2)                                            SHEL 8230
      T13= T32*T(2)-T31*T(5)                                            SHEL 8240
      S =DSQRT(T11**2+T12**2+T13**2)                                    SHEL 8250
      T11=T11/S                                                         SHEL 8260
      T12=T12/S                                                         SHEL 8270
      T13=T13/S                                                         SHEL 8280
      T21= T13*T32-T12*T33                                              SHEL 8290
      T22= T11*T33-T13*T31                                              SHEL 8300
      T23=T12*T31-T11*T32                                               SHEL 8310
      T1(1)=T11                                                         SHEL 8320
      T1(2)=T12                                                         SHEL 8330
      T1(3)=T13                                                         SHEL 8340
      T2(1)=T21                                                         SHEL 8350
      T2(2)=T22                                                         SHEL 8360
      T2(3)=T23                                                         SHEL 8370
      T3(1)=T31                                                         SHEL 8380
      T3(2)=T32                                                         SHEL 8390
      T3(3)=T33                                                         SHEL 8400
      DO 100 I=1,3                                                      SHEL 8410
      J=I+3                                                             SHEL 8420
      K=I+6                                                             SHEL 8430
      T1(J)=T1(I)                                                       SHEL 8440
      T2(J)=T2(I)                                                       SHEL 8450
      T3(J)=T3(I)                                                       SHEL 8460
      CI=T(I)                                                           SHEL 8470
      CJ=T(J)                                                           SHEL 8480
      CK=T(K)                                                           SHEL 8490
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      T1(K)=T11*CI+T12*CJ+T13*CK                                        SHEL8500
      T2(K)=T21*CI+T22*CJ+T23*CK                                        SHEL8510
  100 T3(K)=T31*CI+T32*CJ+T33*CK                                        SHEL8520
  400 A(1)= -T1(1)*A2-T1(2)*B2-T1(3)*C2                                 SHEL8530
      A(2)=  T1(1)*A1+T1(2)*B1+T1(3)*C1                                 SHEL8540
      A(3)= -A(1)-A(2)                                                  SHEL8550
      B(1)=  T2(1)*A2+T2(2)*B2+T2(3)*C2                                 SHEL8560
      B(2)= -T2(1)*A1-T2(2)*B1-T2(3)*C1                                 SHEL8570
      B(3)=-B(1)-B(2)                                                   SHEL8580
      RETURN                                                            SHEL8590
      END                                                               SHEL8600



      SUBROUTINE ODCOS (N,X,Y,Z,T)                                      SHEL8610
C*********************************************************************SHEL8620
C-----THIS SUBROUTINE COMPUTES THE DIRECTION COSINES OF THE LOCAL       SHEL8630
C     ELEMENT SYSTEM OF A QUADRILATERAL(N=4) OR SINGLE TRIANGLE(N=1)    SHEL8640
C*********************************************************************SHEL8650
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL8660
      DIMENSION X(5),Y(5),Z(5),T(9)                                     SHEL8670
      X1 = X(2)+X(3)-X(N)-X(1)                                          SHEL8680
      Y1 = Y(2)+Y(3)-Y(N)-Y(1)                                          SHEL8690
      Z1 = Z(2)+Z(3)-Z(N)-Z(1)                                          SHEL8700
      X2 = X(3)+X(N)-X(1)-X(2)                                          SHEL8710
      Y2 = Y(3)+Y(N)-Y(1)-Y(2)                                          SHEL8720
      Z2 = Z(3)+Z(N)-Z(1)-Z(2)                                          SHEL8730
      S1 = X1**2+Y1**2+Z1**2                                            SHEL8740
      C  = (X1*X2+Y1*Y2+Z1*Z2)/S1                                       SHEL8750
      X2 = X2-C*X1                                                      SHEL8760
      Y2 = Y2-C*Y1                                                      SHEL8770
      Z2 = Z2-C*Z1                                                      SHEL8780
      S1=DSQRT(S1)                                                      SHEL8790
      S2=DSQRT(X2*X2+Y2*Y2+Z2*Z2)                                       SHEL8800
      X1=X1/S1                                                          SHEL8810
      Y1=Y1/S1                                                          SHEL8820
      Z1=Z1/S1                                                          SHEL8830
      X2=X2/S2                                                          SHEL8840
      Y2=Y2/S2                                                          SHEL8850
      Z2=Z2/S2                                                          SHEL8860
      T(1) = X1                                                         SHEL8870
      T(2) = X2                                                         SHEL8880
      T(3) = Y1*Z2-Y2*Z1                                                SHEL8890
      T(4) = Y1                                                         SHEL8900
      T(5) = Y2                                                         SHEL8910
      T(6) = Z1*X2-Z2*X1                                                SHEL8920
      T(7) = Z1                                                         SHEL8930
      T(8) = Z2                                                         SHEL8940
      T(9) = X1*Y2-X2*Y1                                                SHEL8950
      RETURN                                                            SHEL8960
      END                                                               SHEL8970
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      SUBROUTINE DSHELI(AOLD,ANEW,LOAD,NUMDV    )                          SHEL 8980
C*************************************************************************SHEL 8990
C-----DESIGN OF PLATE/SHELL ELEMENTS FOR STRESS CONSTRAINTS                 SHEL 9000
C*************************************************************************SHEL 9010
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                        SHEL 9020
      COMMON/JUNK/JUN(16),LT,LH,L,SG(20),FX,FY,FXY,SMX,SMY,SMXY,SIG,       SHEL 9030
     1 IDVAR,IFX,FRC,H,XINERT,TEN,COMP,SHEAR,BETA,HP(2),JUN1(243)          SHEL 9040
      FXY1=FXY/(SHEAR*H)                                                   SHEL 9050
      SMXY1=6.0*SMXY/(SHEAR*H*H)                                           SHEL 9060
      CC=-1.0                                                              SHEL 9070
      DO 200 I=1,2                                                         SHEL 9080
      IF(I.EQ.2) CC=1.0                                                    SHEL 9090
      C1=FX/H+CC*6.0*SMX/(H*H)                                             SHEL 9100
      C2=FY/H+CC*6.0*SMY/(H*H)                                             SHEL 9110
      AX=TEN                                                               SHEL 9120
      AY=TEN                                                               SHEL 9130
      IF(C1.LT.0.) AX=COMP                                                 SHEL 9140
      IF(C2.LT.0.) AY=COMP                                                 SHEL 9150
      FX1=FX/(AX*H)                                                        SHEL 9160
      FY1=FY/(AY*H)                                                        SHEL 9170
      SMX1=6.0*SMX/(AX*H*H)                                                SHEL 9180
      SMY1=6.0*SMY/(AY*H*H)                                                SHEL 9190
      CXX= FX1*FX1+FY1*FY1+FXY1*FXY1-FX1*FY1                               SHEL 9200
      CX=2.0*(FX1*SMX1+FY1*SMY1+FXY1*SMXY1)- FX1*SMY1-FY1*SMX1             SHEL 9210
      CX=CX*CC                                                             SHEL 9220
      C= SMX1*SMX1+SMY1*SMY1+SMXY1*SMXY1-SMX1*SMY1                         SHEL 9230
      HP(I)=H                                                              SHEL 9240
      DO 100 J=1,10                                                        SHEL 9250
      HHH=(CXX+CX*H/HP(I))*0.5                                             SHEL 9260
      HHH=HHH+SQRT(HHH*HHH+C)                                              SHEL 9270
      HHH=SQRT(HHH)*H                                                      SHEL 9280
      IF(ABS(HHH-HP(I)).LT.0.001) GO TO 200                                SHEL 9290
  100 HP(I)=HHH                                                            SHEL 9300
  200 HP(I)=HHH                                                            SHEL 9310
      HH=HP(1)                                                             SHEL 9320
      IF(HH.LT.HP(2)) HH=HP(2)                                             SHEL 9330
      HH=HH/FRC                                                            SHEL 9340
      IF(HH.LE.ANEW(IDVAR)) GO TO 400                                      SHEL 9350
      ANEW(IDVAR) =HH                                                      SHEL 9360
      LOAD(IDVAR) =L                                                       SHEL 9370
  400 RETURN                                                               SHEL 9380
      END                                                                  SHEL 9390
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```
      SUBROUTINE  BOUND (A,MTOT)                                        BOUN0000
C*************************************************************************BOUN0010
C-----BOUNDARY ELEMENTS                                                 BOUN0020
C*************************************************************************BOUN0030
      DIMENSION A(MTOT)                                                 BOUN0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,NEQBOUN0050
     . ,NUMEL,NUMDV,M1,M2,M3,LL,LB,NEQB,MBLOCK                          BOUN0060
      COMMON/JUNK/JUNK(16),LT,LH,L,SG(27),JUNK1(254)                    BOUN0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                  BOUN0080
      NUME=NPAR(2)                                                      BOUN0090
      IF (NPAR(1).EQ.0) GO TO 500                                       BOUN0100
      CALL CLAMP(A(N1),A(N2),A(N3),A(N4),NUME,NUMNP)                    BOUN0110
      RETURN                                                            BOUN0120
  500 WRITE(IW,2002)                                                    BOUN0130
      DO 800 MM=1,NUME                                                  BOUN0140
      CALL STRSC (A(M),A(N1),A(N3),NEQ,NUMDV,LL,LB,I8,0)                BOUN0150
      DO 800 L=LT,LH                                                    BOUN0160
      CALL STRSC (A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,I8,1)               BOUN0170
      WRITE(IW,3002) MM,L,( SG(I),I=1,2)                                BOUN0180
  800 CONTINUE                                                          BOUN0190
      RETURN                                                            BOUN0200
 2002 FORMAT(//50H ANALYSIS OF BOUNDARY ELEMENTS - CONSTRAINT FORCES // BOUN0210
     154H CONST NUMBER     LOAD CASE          FORCE          MOMENT//)  BOUN0220
 3002 FORMAT (1X,2I10,4X,2E15.5)                                        BOUN0230
      END                                                               BOUN0240
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      SUBROUTINE CLAMP( ID,X,Y,Z,NUME,NUMNP)                            BOUN0250
C*************************************************************************BOUN0260
C-----BOUNDARY ELEMENT MATRICES                                         BOUN0270
C*************************************************************************BOUN0280
      IMPLICIT REAL*8 (A-H,O-Z)                                         BOUN0290
      REAL*4 X,Y,Z,ERC                                                  BOUN0300
      DIMENSION X(NUMNP),Y(NUMNP),Z(NUMNP),ID(NUMNP,6),EMM(86)          BOUN0310
      COMMON/EM/LM(6),S(6,6),P(6,4),XM(6),ST(2,6),TT(2,4),EM1(2444)     BOUN0320
      COMMON/JUNK/R(6),EMUL(4),T(4),IE(5),IX(5),XX(5),YY(5),ZZ(5),U(4), BOUN0330
     1 V(4),JUNK1(216)                                                  BOUN0340
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12                  BOUN0350
      EQUIVALENCE (EMM,S)                                               BOUN0360
      DO 10 I=1,86                                                      BOUN0370
   10 EMM(I)=0.                                                         BOUN0380
C*************************************************************************BOUN0390
C-----CONTROL INFORMATION                                               BOUN0400
C*************************************************************************BOUN0410
      NU=1                                                              BOUN0420
      ND=6                                                              BOUN0430
      NS=2                                                              BOUN0440
      NV=1                                                              BOUN0450
      NW=1                                                              BOUN0460
      IDV=0                                                             BOUN0470
      IEX=0                                                             BOUN0480
      ERC=0.                                                            BOUN0490
      WRITE(IW,2000) NUME                                               BOUN0500
      READ(IR,1005) EMUL                                                BOUN0510
      WRITE(IW,2005) EMUL                                               BOUN0520
C*************************************************************************BOUN0530
C-----ELEMENT CARDS                                                     BOUN0540
```

```
C*****************************************************************************BOUN0550
      WRITE(IW,2001)                                                          BOUN0560
      N=1                                                                     BOUN0570
  200 READ(IR,1000) IEL,IF,KD,KR,INC,SD,SR,TRACE                             BOUN0580
      IF(KD.NE.1) KD=0                                                        BOUN0590
      IF(KR.NE.1) KR=0                                                        BOUN0600
      IF(INC.EQ.0) INC=1                                                      BOUN0610
      IF(TRACE.EQ.0.) TRACE= 1.0E 10                                          BOUN0620
      KK=INC*(IEL-N)                                                          BOUN0630
      DO 100 I=1,5                                                            BOUN0640
  100 IX(I)=IF(I)-KK                                                          BOUN0650
      IF(IF(3).NE.0) GO TO 210                                                BOUN0660
      DO 101 I=3,5                                                            BOUN0670
  101 IX(I)=0                                                                 BOUN0680
  210 DO 550 NEL=N,IEL                                                        BOUN0690
      DO 110 I=1,5                                                            BOUN0700
      II=IX(I)                                                                BOUN0710
      IF(II.EQ.0) GO TO 110                                                   BOUN0720
      XX(I)=X(II)                                                             BOUN0730
      YY(I)=Y(II)                                                             BOUN0740
      ZZ(I)=Z(II)                                                             BOUN0750
  110 CONTINUE                                                                BOUN0760
      IF(IX(3).EQ.0) GO TO 250                                                BOUN0770
      CALL VECTOR(U,XX(2),YY(2),ZZ(2),XX(3),YY(3),ZZ(3))                      BOUN0780
      CALL VECTOR(V,XX(4),YY(4),ZZ(4),XX(5),YY(5),ZZ(5))                      BOUN0790
      CALL CROSS(U,V,T)                                                       BOUN0800
      GO TO 260                                                               BOUN0810
  250 CALL VECTOR(T,XX(1),YY(1),ZZ(1),XX(2),YY(2),ZZ(2))                      BOUN0820
  260 DO 50 J=1,3                                                             BOUN0830
      ST(1,J  )=T(J)*TRACE*KD                                                 BOUN0840
      ST(2,J+3)=T(J)*TRACE*KR                                                 BOUN0850
      R(J  )=T(J)*TRACE*SD*KD                                                 BOUN0860
      R(J+3)=T(J)*TRACE*SR*KR                                                 BOUN0870
      DO 50 I=1,J                                                             BOUN0880
      S(I  ,J  )=T(I)*T(J)*TRACE*KD                                           BOUN0890
   50 S(I+3,J+3)=T(I)*T(J)*TRACE*KR                                           BOUN0900
      DO 500 I=2,6                                                            BOUN0910
      II=I-1                                                                  BOUN0920
      DO 500 J=1,II                                                           BOUN0930
  500 S(I,J)=S(J,I)                                                           BOUN0940
      DO 520 J=1,4                                                            BOUN0950
      TT(1,J)=-TRACE*KD*SD*EMUL(J)                                            BOUN0960
      TT(2,J)=-TRACE*KR*SR*EMUL(J)                                            BOUN0970
      DO 520 I=1,6                                                            BOUN0980
  520 P(I,J)=R(I)*EMUL(J)                                                     BOUN0990
      II=IX(1)                                                                BOUN1000
      DO 600 I=1,6                                                            BOUN1010
  600 LM(I)=ID(II,I)                                                          BOUN1020
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,ERC)               BOUN1030
      WRITE(IW,2100) NEL,IX,KD,KR,SD,SR,TRACE                                 BOUN1040
      IX(1)=IX(1)+INC                                                         BOUN1050
      IX(2)=IX(2)+INC                                                         BOUN1060
      IF(IX(3).EQ.0) GO TO 550                                                BOUN1070
      DO 650 I=3,5                                                            BOUN1080
  650 IX(I)=IX(I)+INC                                                         BOUN1090
  550 CONTINUE                                                                BOUN1100
      N=IEL+1                                                                 BOUN1110
      IF(N.LE.NUME) GO TO 200                                                 BOUN1120
      RETURN                                                                  BOUN1130
 1000 FORMAT(9I5,5X,3E10.0)                                                   BOUN1140
```

```
 1005 FORMAT (4E10.0)                                                   BOUN1150
 2000 FORMAT(34H1 B O U N D A R Y  E L E M E N T S //                    BOUN1160
     1 23H NUMBER OF ELEMENTS    =,I5  )                                BOUN1170
 2001 FORMAT(//22H BOUNDARY ELEMENT DATA //                             BOUN1180
     1 5X,5HCONST,5X,4HNODE,42H /--NODES DEFINING CONSTRAINT DIRECTION--BOUN1190
     2/,5X,5HCODES, 8X,5HDISPL,5X,8HROTATION,4X,5HSTIFF /              BOUN1200
     3 4X,6HNUMBER,6X,1HN,8X,2HNI,8X,2HNJ,8X,2HNK,8X,2HNL,6X,2HKD,3X,  BOUN1210
     4 2HKP,11X        ,1HD,11X,1HP,11X,1HS  )                         BOUN1220
 2005 FORMAT (//   25H ELEMENT LOAD MULTIPLIERS//                       BOUN1230
     . 9X,1HA,9X,1HB,9X,1HC,9X,1HD /4E10.4)                             BOUN1240
 2100 FORMAT(I7,5I10,3X,2I5,5X,1P3E12.2)                                BOUN1250
      END                                                               BOUN1260
```

```
      SUBROUTINE TRUSS  (A,MTOT)
      DIMENSION A(MTOT)
      WRITE(6,202) .
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE TRUSS     ',//)
      END



      SUBROUTINE BEAM  (A,MTOT)
      DIMENSION A(MTOT)
      WRITE (6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE BEAM      ',//)
      END



      SUBROUTINE  PLANE (A,MTOT)
      DIMENSION A(MTOT)
      WRITE  (6,202 )
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE PLANE     ',//)
      END



      SUBROUTINE SHEAR  (A,MTOT)
      DIMENSION A(MTOT)
      WRITE  (6,202 )
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE SHEAR     ',//)
      END



      SUBROUTINE SHELL(A,MTOT)
      DIMENSION A(MTOT)
      WRITE(6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE SHELL     ',//)
      END



      SUBROUTINE BOUND(A,MTOT)
      DIMENSION A(MTOT)
      WRITE(6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE BOUND     ',//)
      END
```